Marshall Space Flight Center

FY 2001 Annual Report

FY 2001 Annual Report: Statement of the Director

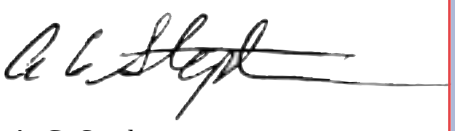
The year 2001 proved once again that the Marshall Team is dedicated to the mission of the Center and the Agency, excelling in our three mission areas: Space Transportation Systems Development, Microgravity, and Space Optics Manufacturing Technology. Our successes started with our commitment to safety; and our dedication to Marshall's core values was evident throughout each program, assignment, and challenge.

The year 2001 was highlighted with the 20th anniversary of the first Shuttle launch—STS–1. The Marshall Center hosted an exciting celebration to pay tribute to the STS–1 crew, and to reflect on the enormous contributions Marshall Space Flight Center makes to the Shuttle program. The Marshall Center also marked two important milestones: in October 2001 the *International Space Station* celebrated 1-year of continuous habitation, and the Chandra X-ray observatory marked its 2-year anniversary in space.

During 2001, many exciting accomplishments took place at Marshall. In Space Transportation Systems Development, accomplishments included the showcase of the new Block II Main Engine configuration and the External Tank Project's implementation of state-of-the-art digital x-ray technology. In addition, the Solid Rocket Booster hardware performed nominally for the seven FY 2001 Shuttle missions, and the Reusable Solid Rocket Motor team celebrated its 11th continuous year of on-schedule deliveries to the Kennedy Space Center. Another important achievement was the creation of the new 2nd Generation Reusable Launch Vehicle (RLV) Program Office, making the Space Launch Initiative (SLI) an official part of the MSFC organization.

Other important program highlights involved the Microgravity and Space Products Development Programs, which continued to deliver scientific and commercially developed payloads. Also, the Space Optics Manufacturing Technology Center continued with its important work on new materials and assembly techniques to make giant reflectors for launch into space. The X-ray Calibration Facility staff continued to improve processes that allow around-the-clock operation; and the Flight Projects Directorate celebrated the delivery of the U.S. Joint Airlock, Quest, to the *International Space Station*. The airlock, which was built and tested at Marshall Space Flight Center, was delivered in July 2001 by the crew of STS–104.

I am pleased with the accomplishments of FY 2001. The example the Marshall Center has set is an honorable one. Our success is due to the outstanding dedication of our workforce. Without dedication, these noteworthy accomplishments would not have been possible. I look forward to leading the Marshall Space Flight Center through another incredible year.



A. G. Stephenson
Director


NASA
NASA/MSFC Vision
To improve life here,
To extend life to there,
To find life beyond.
NASA´s Mission
To understand and protect our home planet,
To explore the Universe and search for life,
To inspire the next generation of explorers...
as only NASA can.
MSFC´s Mission
To enable, through our values-based culture,
the unbounded access to and
use of space to benefit humanity.
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Table of Contents

Marshall Values

The Marshall Space Flight Center team is committed to these core values.

People:

- **We** recognize that the people who work here are "most important"—and are our greatest strength.
- **We** create a safe and healthy environment.
- **We** encourage balance between personal and professional life.
- **We** enable personal and professional growth.
- **We** commit ourselves to the highest standards of integrity and ethical behavior.
- **We** reward and celebrate our accomplishments.
- **We** recognize individual and cultural differences and treat each other with dignity and respect.

Customers:

- **We** are accountable to our customers and are committed to their satisfaction.
- **Our** customers can depend on us to deliver quality products and services.

Excellence:

- **We** pursue excellence in our people and in everything we do.
- **We** promote continual learning and improvement.
- **We** hold one another accountable for doing what we commit to do.

Teamwork:

- **We** are a unified and interdependent team.
- **We** cooperate, communicate openly, and share ideas with each other for the common good.
- **We** seek and enable partnerships with other NASA Centers, other agencies, academia, industry, and our local and global communities.

Innovation:

- **We** promote innovation and creativity.
- **We** seek different ideas and perspectives.
- **We** are committed to making a significant difference.
- **We** are willing to accept well-assessed, selected risks in the pursuit of our goals—but never at the expense of safety.

These values serve as the principles that guide our decisions and behavior.

Marshall Space Flight Center FY 2001 Annual Report

Introduction

The Marshall Space Flight Center (MSFC), a field Center of the National Aeronautics and Space Administration (NASA), was established on July 1, 1960, with the transfer of land, buildings, property, space projects, and personnel from the United States Army.

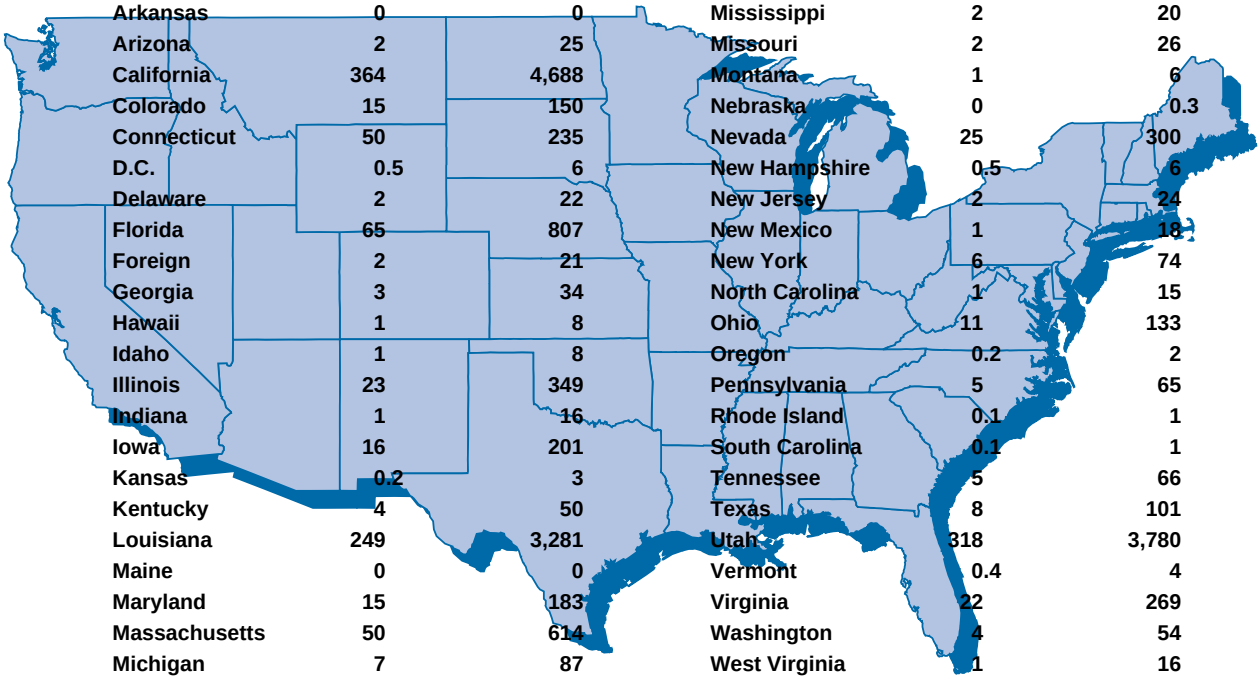
Dr. Wernher von Braun was named the Center's first director. Under von Braun's guidance, MSFC's Mercury-Redstone vehicle boosted America's first astronaut on a suborbital flight in 1961.

MSFC's first major program was the development of the Saturn rockets, the largest of which began sending man to the moon in 1969 and Skylab into orbit in 1973. Other successful projects in MSFC's history include the three Lunar Roving Vehicles, the three High Energy Astronomy Observatories, the Hubble Space Telescope, the Chandra X-Ray Observatory, and the MSFC-developed propulsion systems which launched America's first Space Shuttle.

MSFC is the Center of Excellence for Space Propulsion and provides leadership in space transportation development, microgravity, and space optics manufacturing technology. MSFC is a vital resource for the development and utilization of key scientific missions that will advance the frontiers of knowledge and human exploration. Our commitment to mission success is evidenced not only by our accomplishments over the past year, but also our dedication and our focus on the future.

MSFC FY01 Dollars and Workforce by Benefiting State

State	FY01 $Millions	FY01 Jobs
Alabama	829	9,531
Arkansas	0	0
Arizona	2	25
California	364	4,688
Colorado	15	150
Connecticut	50	235
D.C.	0.5	6
Delaware	2	22
Florida	65	807
Foreign	2	21
Georgia	3	34
Hawaii	1	8
Idaho	1	8
Illinois	23	349
Indiana	1	16
Iowa	16	201
Kansas	0.2	3
Kentucky	4	50
Louisiana	249	3,281
Maine	0	0
Maryland	15	183
Massachusetts	50	614
Michigan	7	87
Minnesota	11	136
Misc. Unidentified	70	861
Mississippi	2	20
Missouri	2	26
Montana	1	6
Nebraska	0	0.3
Nevada	25	300
New Hampshire	0.5	6
New Jersey	2	24
New Mexico	1	18
New York	6	74
North Carolina	1	15
Ohio	11	133
Oregon	0.2	2
Pennsylvania	5	65
Rhode Island	0.1	1
South Carolina	0.1	1
Tennessee	5	66
Texas	8	101
Utah	318	3,780
Vermont	0.4	4
Virginia	22	269
Washington	4	54
West Virginia	1	16
Wisconsin	5	64
MSFC Total	2,202	26,362



Safety and Mission Assurance

The Marshall Space Flight Center (MSFC) and the Safety and Mission Assurance (S&MA) Office have made significant progress regarding commitment to safety and mission success. The S&MA goal is to establish MSFC as number one in safety within NASA. Striding towards that goal, MSFC strives to prevent human injury and occupational illnesses and ensure the safety of all operations and products. S&MA believes that mission success starts with safety, and this policy includes the public, astronauts and pilots, the NASA workforce, and high-value equipment and property. This unique and innovative management approach is designed to improve safety at MSFC. Looking forward to future activities at MSFC, it can be noted that the S&MA team is an intricate partner in every project and activity, and will continue onward with these efforts, both now and in the future.

S&MA is committed to achieving excellence and is poised to support this role through various safety processes and activities. One such activity is an Occupational Safety, Health, and Environmental (SHE) Committee, which assists in steering the MSFC safety program. Participation from top managers through line supervisors, an employee safety action team, and a contractor safety forum assures that safety is in focus at MSFC. An interactive Web site, the SHE Web site, has been designed and is fully operational with the latest information concerning safety, health, and environmental issues. The highlight of the SHE Web site is its ease of use, from the Who-to-Call area to its links to other Web sites containing pertinent safety information. Another outstanding feature is its easy access to documentation databases that contain the Integrated Document Library, policies, and procedures. There is also an area containing past and present safety bulletins and newsletters. Also, upcoming training courses in the areas of safety, health, and the environment can be easily found on the Web site. The SHE Web site also provides access to the Safety Concerns Reporting System (SCRS). The SCRS has been greatly improved and is frequently used by MSFC employees to report their concerns. This Web site can also be used to report mishaps and close calls.

The S&MA team is organized to effectively support the MSFC organizational structure while maintaining colocation in major project offices and contractor plants. This strategy has proven to be invaluable in meeting the assigned roles and missions at task. S&MA is also working hard to ensure that safety communications reach all levels of civil service and contractor employees. To meet this initiative, all MSFC managers, supervisors, and employees have been trained in MSFC's new occupational safety and health philosophy and processes. All onsite contractor employees have been provided with safety and health training. All major management meetings include a safety discussion. Managers and supervisors conduct monthly safety meetings, perform monthly workplace occupational safety and health audits with employees, and ensure that employees have appropriate safety training. The culmination of these activities is the availability of safety information in various formats and media, ensuring that everyone at MSFC believes that safety is the key to the Center's success and well-being.

During FY 2001, one of S&MA's safety initiatives included using the Agency Safety and Health Initiative Model to continue improvements in the MSFC safety program, as S&MA works toward receiving the Occupational Safety & Health Administration (OSHA) Voluntary Protection Program Star Certification. MSFC's safety principles state that:

- Unsafe conditions are correctable.
- All mishaps can be prevented.
- Management is responsible and accountable for the prevention of on-the-job mishaps.
- All mishaps must be reported, investigated, and the causes rectified.
- Management is responsible for training employees to work safely.
- Each employee is responsible for safety.
- Off-duty safety is an important part of MSFC's safety success.
- A comprehensive safety and risk management program increases the probability of mission success.

The S&MA safety program works because of management commitment and employee involvement. An example of this can be found in the implementation of a Web-based Supervisors' Safety Web Page (SSWP) program that assists supervisors in conducting monthly safety meetings and walk-throughs and tracking any subsequent actions.

All of these activities have led to a workforce that is more knowledgeable about safety. Safety Moments have shown that reinforcement of the safety philosophy and processes has succeeded beyond just the MSFC workplace. S&MA has heard many stories of how employees are more aware and safety conscious outside of the workplace. Safety First has become a part of their life.

Safety policy documents require safety analyses for all new potentially hazardous operations and facilities. Hazard analyses performed in FY 2001 included transportation of key *International Space Station* hardware.

FY 2001 Safety and Mission Assurance Metrics and Performance

Achieve a world-class lost-time mishap rate of .10 or less with the ultimate goal of 0.

The FY 2001 civil service lost-time rate of .09 met the goal. MSFC onsite contractors experienced a rate of .36. The combined MSFC civil service and contractor lost-time mishap rate of .27 did not meet the Center's goal of .10. A proactive SHE training initiative contributed to increased awareness and reporting.

All MSFC projects successfully complete their safety reviews on time.

MSFC supported 4 in-house Payload Safety Readiness Review Boards and successfully completed 31 Johnson Space Center/ Kennedy Space Center Payload Safety Reviews on time during FY 2001. MSFC coordinated and hosted the Aerospace Safety Advisory Panel. All Shuttle Program safety reviews were successfully completed, and no delta reviews were required. There were seven flights without an in-flight anomaly from Space Shuttle Main Engine (SSME) start to SSME cutoff. NASA's operations demonstrate high levels of safety consciousness and sincere efforts to place safety first.

Marshall Safety First Class

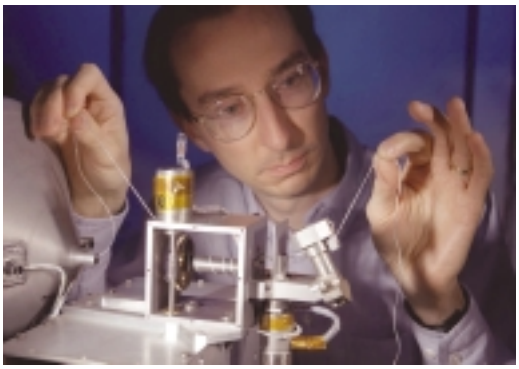
Center of Excellence: Space Propulsion

As NASA's designated Center of Excellence for space propulsion research, the Marshall Space Flight Center (MSFC) manages development, implementation, and advocacy of advanced Earth-to-orbit and in-space propulsion systems and technologies that are critical to enabling a new generation of space missions. The MSFC's overriding emphases are on safety, reliability, and a high return on investments in terms of scientific, commercial, and overall mission value—thereby enhancing U.S. industrial growth, preserving its leadership role in burgeoning space markets, and improving the quality of life on Earth.

It is the responsibility of MSFC to maintain and continuously improve the skilled personnel, processes, facilities, and support factors needed to accomplish these goals. MSFC also supplies cross-cutting support to all related NASA enterprises and to all its partners and allies, including other NASA field Centers, industry, academia, and Government organizations.

High Performance Antimatter Trap.

Pulse detonation concept.



Nonconducting part of a tether is inspected as it exits a deployer similar to the system to be used in NASA's ProSEDS flight experiment.

Space Transportation Systems Development

The Space Shuttle Projects Office

The Space Shuttle—the most sophisticated human spacecraft in the world and the world's primary reusable system for human space travel—celebrated its 20th anniversary and 100th flight this year.

Since 1970, the Marshall Space Flight Center (MSFC) has been at the forefront of the Space Shuttle Program. MSFC continues to manage the Shuttle's External Tank (ET), Solid Rocket Boosters (SRB)—which include the Reusable Solid Rocket Motors (RSRM), and its Main Engines, the propulsion system that lifts the Shuttle off the launch pad.

During FY 2001, the Space Shuttle flew seven flawless missions, with no launch delays attributed to the MSFC propulsion elements. Five of those flights were flown within seven months—a tribute to the expertise and diligence of the entire Shuttle team and to NASA as an agency dedicated to safety first and the continuing exploration of space.

Shuttle Integration Office

The Shuttle Integration Office (SIO) plays an integral role in the Space Shuttle Projects (SSP) Office at MSFC, serving as the organization that integrates systems engineering, provides launch support, and maintains the business and administrative side of the program. For example, SIO manages activities related to Shuttle launch simulations, prelaunch testing, and related data management for the Huntsville Operations Support Center. It deals directly with review requirements and issue resolutions on the Main Propulsion System; promotes environmental excellence and proactively manages materials obsolescence through the Shuttle Environmental Assurance (SEA) Initiative; and manages all electromagnetic effects-related changes by reviewing, coordinating, and tracking impacts to program requirements. SIO also cultivates and coordinates outreach into the community, this year reaching more than 86,000 people and traveling to six states taking exhibits to events, providing school tours, lectures, and training activities.

Space Shuttle Main Engine

Block II Engine

On July 12, 2001 the world heard the roar of the first Block II Space Shuttle Main Engine (SSME) when it flew for the first time on STS–104. The maiden flight was a single Block II Engine clustered with two Block IIA Engines. All flights subsequent to STS–109 will be flown with Block II Engines in all three orbiter positions.

The Block II Engine is an upgrade from the Block IIA Engine, which has been flying since STS–89. The most significant improvement is the new Block II High-pressure Fuel Turbopump (HPFTP). This turbopump replaces the HPFTP used on both the Block I and Block IIA SSMEs, which served the program very well since the first Shuttle flight, STS–1 in 1981. The Block II HPFTP improves the engine's reliability, safety margins, and life, while it reduces maintenance and overhaul costs. Because of the Block II HPFTP's incorporation, the reliability of the SSME is a 28 percent improvement over the Block IIA.

Space Shuttle Main Engine (SSME).

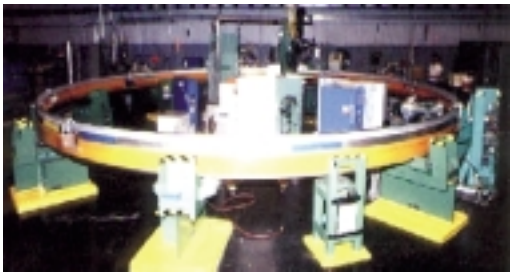
Advanced Health Management System

The Advanced Health Management System (AHMS) is a two-phase, high-priority Shuttle safety upgrade project that, when implemented, will reduce SSME catastrophic ascent risk by more than 40 percent. This risk reduction comes through the application of improved high-pressure turbopump vibration sensing technology combined with advanced health management

algorithms, engine modeling, and real-time signal processing technology. Additionally, implementation of AHMS Phase 2 will introduce two new potential mitigation actions for SSME failures—single engine throttle-down and mixture ratio adjustment. These failure mitigation actions, when taken in lieu of engine shutdown, will enable the Shuttle to achieve a safer abort mode or possibly even turn what would otherwise be an abort into a successful mission.

The SSME AHMS Project achieved several key requirements and design milestones in FY 2001. For Phase 1, the Critical Design Review (CDR) was conducted on schedule in May 2001, completing the detailed hardware design phase and initiating flight hardware fabrication. For Phase 2, the Program Requirements Review (PRR) was conducted in November 2000, from which the SSP requirements baseline was established. The System Requirements Review (SRR) was conducted in February 2001, followed by the System Definition Review (SDR), which was completed in August 2001. The Phase 2 project formulation effort concluded on schedule with the presentation of a request for authority to proceed into implementation to the SSP Office in September.

External Tank at Kennedy Space Center.



T-ring weld and x-ray tool.

External Tank

ET implemented state-of-the-art digital x-ray technology that will improve processing time and increase flaw detection capability. The liquid hydrogen (LH_2) tank, liquid oxygen (lox) tank, and the intertank, which joins the two pressure vessels, consist of over 36,000 inches of welded joints. The previous method of weld joint verification film radiography was time consuming, difficult to interpret, required environmental disposition of film processing chemicals, and needed significant storage volume to maintain processed x-ray film. Digital x-ray images can be produced in a fraction of the time, are much easier to interpret, are environmentally friendly, and can be stored on a computer disk.

A fairly simple application, the T-ring weld and x-ray tool, was chosen for first implementation to prove the concepts and develop operator capability. The second application, the dome digital x-ray tool, is scheduled for implementation in December 2002. Thus far, expectations have been met or exceeded in every respect. The digital radiography system is reducing production-cycle time and producing superior results for weld quality verification.

External Tank Friction Stir Weld safety upgrade

Training hardware, facility modifications, and the initial production tooling have all been completed in support of the July 2002 implementation of Friction Stir Welding (FSW) in the ET production line. FSW, which will be used on the liquid oxygen and liquid hydrogen barrel section longitudinal welds, will provide an increased safety margin and reduce the manufacturing cost and schedule.

The FSW trainer tool, a 1/4-scale replication of the production tool, was delivered to the Michoud Assembly Facility (MAF) in October 2001. Facility modifications, which included the construction of a 90-ft long, 50-ft wide, and 15-ft deep pit to house the production tooling, was completed on time without interference with the ongoing ET manufacturing. Several risk mitigation steps have been implemented on this project to ensure its successful implementation. One of the more notable items surfaced by the risk mitigation plan was the potential for a lack-of-penetration in the tapered barrel sections. This risk has been mitigated by the addition of a retractable-pin FSW tool that includes laser sensors to allow real-time compensation for thickness variations that occur in the tapered welds.

All elements of the FSW project are on schedule to support implementation in July 2002 and will be a major enhancement to the producibility and safety of the Space Shuttle's ET.

Lean Manufacturing/Statistical Process Control

An aggressive lean manufacturing/statistical process control plan is underway and showing improvements in quality and cost metrics. Targeted worksites undergo a week-long Kaizen events analysis to optimize workspace and workflow. Statistical process control is employed as a follow-up to systematically refine and reduce

process variability. As part of this effort, metrics are developed to evaluate long-term success.

Performance measurements on converted worksites confirm improvements in quality, cost, required manufacturing floor space, and part and employee travel distance.

External Tank Paperless Manufacturing Execution System

In FY 2003, all work orders and supporting documentation required to assemble an ET will be generated and processed electronically. This new system will provide improvements in work instruction, nonconformance documentation quality, process control, and operational efficiency. To prepare for this transition and to substantiate the benefits prior to implementation, a Paperless Manufacturing Pilot Center was established. Teams of operators and engineers spent several months reviewing the capabilities and limitations of various products. Following this demonstration in FY 2001, the project was approved for implementation.

Concurrent with the implementation of this new capability, a fiber optic network is being installed to support the increased capacity requirements of the paperless system.

Following implementation in FY 2003, ET manufacturing will see improved efficiency, reliability, and productivity.

Reusable Solid Rocket Motor

Ensuring ontime delivery and ontarget performance is a continual focus for the RSRM Project. For the 11th consecutive year, all motor segments were delivered on schedule. Postflight disassembly and inspections during FY 2001 revealed no significant anomalies. All flown RSRMs performed as designed.

Reusable Solid Rocket Motor Independent Assessment

The SSP Office chartered an independent team to assess RSRM operations relative to a broad spectrum of program issues. The team, utilizing independent retired NASA and corporate members, conducted their review at ATK Thiokol on March 4–9, 2001. Focus areas of the audit included:

- Facilities, equipment, and tooling.
- Nondestructive Evaluation (NDE) processes.
- Material-receiving inspection practices.

The final report issued on April 11, 2001 concluded that:

- The RSRM is meeting all performance requirements.
- The ATK Thiokol workforce is attuned to the criticality of process control to RSRM safety.
- Facilities, equipment, and tooling are in good condition and being maintained in an effective manner.
- Inspection and NDE tooling and equipment are meeting existing requirements and are maintained in good operating condition.
- Materials-receiving inspection is thorough and geared to detecting inferior products. However, these vendor products represent a risk to the RSRM program that requires careful management.

RSRM flight support motor firing.

Paperless Manufacturing Execution System Workstation.

Reusable Solid Rocket Motor Obsolescence Mitigation.

The RSRM is unique. It is comprised of diverse categories of uncommon processes, materials, and components that face the constant challenges presented by obsolescence issues that have the potential to adversely affect the RSRM. Continuous surveillance is required to anticipate and implement the necessary replacement technologies to manufacture and deliver the RSRM with unaltered configuration and performance characteristics.

Automated Eddy Current Inspection Systems for Reusable Solid Rocket Motor Refurbishment

During after-flight refurbishment, all RSRM hardware is cleaned to bare metal and subjected to numerous inspections: visual, dimensional, and NDE (proof test, magnetic particle, dye penetrant, eddy current, ultrasonic shearwave, etc.). Magnetic particle and dye penetrant inspections are visual-based, i.e., they rely on the human eye as the sensor to detect indications. Although these visual-based inspections are supported by extensive probability-of-detection studies and history, new electronic sensor-based inspections offer advantages. The RSRM project will replace these visual-based inspections with sensor-based inspections to improve the reliability, control, and data storage of NDEs. Using sensors also allows automation of the inspection. Other benefits include the digital evaluation of indications, the ability to calibrate, the archiving of data, the reduction of cycle time, the reduction of waste streams, and the elimination of inspector variability and subjectivity.

Delivery and installation occurred in early 2001, with testing successfully conducted on full-scale hardware, including Flight Support Motor No. 10 (FSM–10). Following the successful completion of qualification testing, implementation of the new systems as a replacement for some of the current inspections is planned to begin in early 2002.

Digital X-ray Inspection for Reuseable Solid Rocket Motor Components

An effort is underway to develop and demonstrate state-of-the-art digital x-ray systems that will eventually replace the current wet-film technology used since the inception of the Solid Rocket Motor/RSRM program. This new inspection technique, which actually uses the same x-ray energy source as the current system, will be used to provide the NDE of phenolic-nozzle components as well as loaded and insulated motor segments.

The digital image is captured on fluorescent screens and converted to a computer screen where the image can be evaluated, enhanced, and stored as a digital file for future reference. The new digital system provides better image quality as well as improved image manipulation and enhancement capabilities. The digital data will be stored electronically to allow for near-instantaneous retrieval of all images, making anomaly investigations and other data review activities more efficient.

Nozzle-to-Case Joint J-Leg Configuration

The current RSRM nozzle-to-case joint employs a polysulfide mastic adhesive bondline as a thermal barrier in an effort to preclude gas penetration to the O-ring sealing system. In an effort to reduce or eliminate the occurrence of gas paths through the polysulfide, a design change that eliminates the polysulfide and incorporates a J-leg with a carbon rope thermal barrier is being tested.

The RSRM nozzle-to-case J-leg incorporates a pressure actuated flap (J-leg) insulation design that, when deflected, is placed in circumferential tension in the assembled state, similar to a stretched rubberband. An enhancement for the J-leg configuration is the installation of a carbon rope thermal barrier that is located at the step region of the joint. In the event of gas leakage beyond the J-leg region, the thermal barrier will cool and spread any gas, thus eliminating potential heat effects on the outboard leak check barrier.

FY 2001 accomplishments include the firing of FSM–9, which was

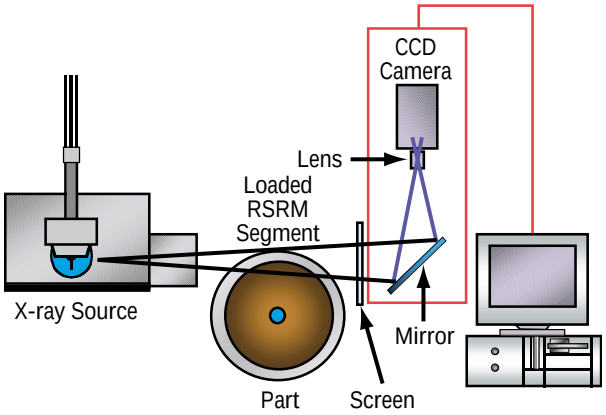
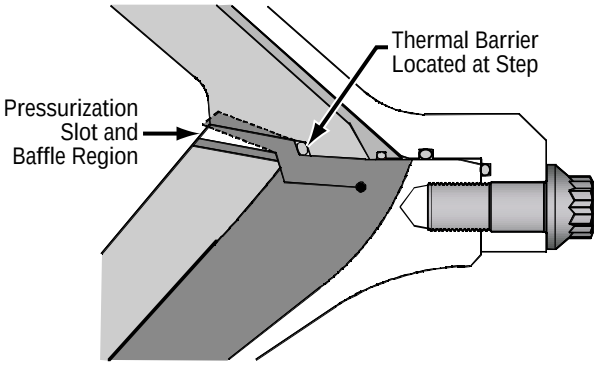


Illustration of Digital X-ray Inspection System.



Nozzle-to-Case Joint J-leg Configuration.

the first full-scale static test with the improved J-leg configuration. The joint performed its intended function by keeping hot gas away from the joint seals. No hot gas penetration past the J-leg or the carbon rope thermal barrier was observed. The next full-scale static test, FSM–10, will include a channel through the J-leg to the thermal barrier. FSM–10 hardware is currently being fabricated and will be fired in August of 2002.

Flight Support Motor No. 9

Full-scale RSRM static test motors are periodically tested to confirm the performance and safety of RSRM systems and certify design, component, material, and process changes. FSM–9 was successfully static tested May 24, 2001. Extensive instrumentation (576 channels) gathered data in support of the 103 test objectives. While data evaluation continues, the FSM–9 test was a complete success.

Solid Rocket Booster

SRB hardware performed nominally for the seven FY 2001 Shuttle missions. In FY 2001, several significant activities were initiated that will make hardware safer and more reliable, and make processes more efficient. They are:

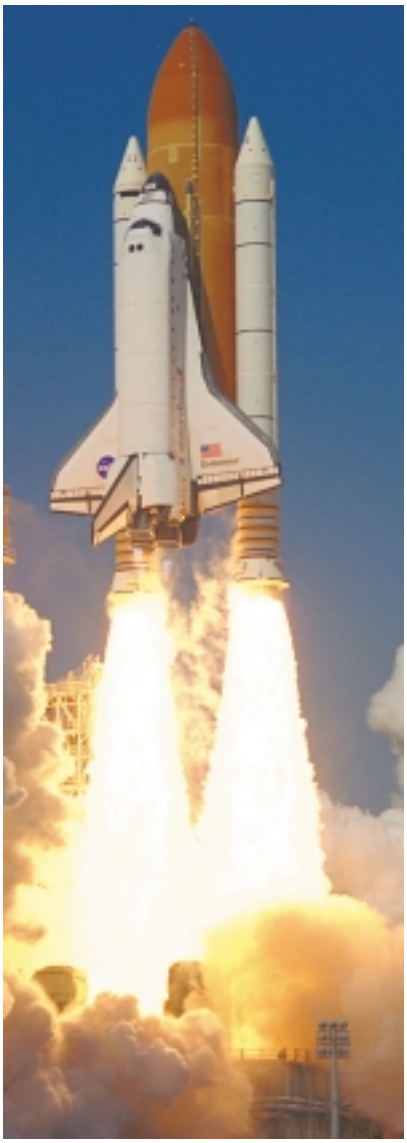
- The Range Safety System's new improved Command Receiver Decoder (CRD) passed qualification testing. The CRD was developed to replace the range safety distributor and the integrated receiver/decoders on each SRB.

- An Independent Operations Assessment Team concluded that, with the addition of recommended improvements, the SRB operations "are well postured to support the Space Shuttle manifest in the foreseeable future."

- Due to concerns over aging electronics issues on Shuttle and other NASA spacecraft and the anticipated qualification-life expiration of some of the SRB electronics, the project chartered a special independent team to assess the Integrated Electronics Assembly (IEA) for age or wear-out concerns. The IEA Supportability Assessment Team (ISAT) was chartered to assess the impact to the ability of the SRB IEAs to support the shuttle manifest and to provide recommendations along with a roadmap for the design and implementation of proposed upgrades to the project. The ISAT performed an exhaustive historical review of the failures and anomalies of the IEA, reviewing and consolidating over 11,000 reports from three separate databases. During reviews of the ISAT results, it was recognized by outside organizations that this complete and thorough data analysis approach should be used by all project elements in the development of supportability issues, including the identification of maintenance and failure trends.

- Booster-separation motor problems have led to improved manufacturing and testing processes. A major United Space Alliance (USA) supplier implemented a closed loop procedure to track and verify that there would not be any adverse affects to flight safety due to process changes.

- Reassessment of SRB cables is leading towards many improvements.



Lift-off of STS–99 from launch pad 39A.

- The SRB Project has made significant progress on the Thrust Vector Control upgrade, selecting the Helium Auxiliary Power Unit as the replacement system. The project has successfully completed the PRR and a combined SRR/SDR.

- Pyrotechnic issues have led to many proactive enhancements that will mitigate concerns in the future.

FY 2001 Space Shuttle Projects Office Metrics and Performance

Space Shuttle Main Engine

Maintain less than one in-flight anomaly per mission.

The SSME Project completed FY 2001 with no in-flight anomalies (IFAs) attributable to the SSME.

Meet the Manifest.

The SSME Project met all launch dates during FY 2001 with no delays, aborts, or scrubs. In addition, the alternate HPFTP made its first flight on STS–104, July 12, 2001.

Maintain safety performance records at our contractor facilities which exceed industry standards.

The SSME prime contractor continued to exceed industry standards for safety performance during FY 2001.

External Tank

Maintain less than one in-flight anomaly per mission.

Seven ETs were flown in FY 2001 and no IFAs were experienced during any flight. They performed as designed with no significant problems.

Safety.

Monthly walk-through inspections of the ET Project's area of operations are conducted. Any discrepancies are resolved immediately. Results of the inspection are posted conspicuously in the area for all employees to read. The results are also reported through the Supervisors' Safety Web Page (SSWP). Senior leadership has access to the Web site and may use this tool to ensure that project managers are conducting both safety walk-throughs and monthly meetings.

Monthly meetings are organized and conducted at the Shuttle level. ET participates in these meetings regularly and maintains a sign-in sheet for each meeting to monitor attendance. Attendance is also reported on the SSWP.

Contractor Safety.

Safety performance records at our contractor facilities that exceed industry standards are maintained. The metrics that Lockheed Martin (LM) Space Systems Company (LMSSC), Michoud Operations, looks at are the ones set by the Bureau of Labor and Statistics (BLS), and they must maintain 50 percent of that number or less. The three metrics set by BLS are:

1. Occupational Safety and Health recordable case rate (BLS metric 2.2) (LM current number 2.4).
2. Lost workday case rate (BLS metric 1.1) (LM current number 1.7).
3. Day away from work case rate (BLS metric .6) (LM current number .09). The LM current numbers were evaluated from February 2001 to February 2002.

Michoud Assembly Facility.

LMSSC continues to excel in their safety awareness training (2,221 employees received safety awareness training in CY 2001). Lockheed Martin performed 12 formal safety walk-throughs this reporting period and, no major safety issues were identified. In addition, LMSSC, Michoud Operations, performs 140 informal safety walk-throughs per month. To date, no major safety issues have been identified.

Enhance safety, assure mission supportability and sustain the life of the Shuttle. To improve the reliability of the Space Shuttle, propulsion system upgrades, such as the following, are to be incorporated:

- *External Tank Friction Stir Welding.*
- *Space Shuttle Main Engine Advanced Health Management.*
- *Reusable Solid Rocket Motor Propellant Grain Geometry Modification.*
- *Solid Rocket Booster Advanced Thrust Vector Control.*

Development has progressed to the point that all FSW tooling is in the process of being delivered to the MAF for installation and checkout.

Meet the manifest.

The ET Project continued to support Meet the Manifest and Improve Mission Supportability Metrics throughout FY 2001. "Six-sigma" statistical process control weld teams joined existing thermal protection coating process control teams to improve in-process capability and consistency. Build process teams partnered management, engineering, quality, and practitioners in developing production best practices and improved safety. Robust process improvement, lean manufacturing, and Kaizen event initiatives continued to streamline build areas while reducing cost and defect rate. Ongoing implementation of state-of-the-art digital versus conventional x-ray NDE for tank-frame and dome welds will provide time and cost savings, and enhance x-ray image storage and mobility.

Reusable Solid Rocket Motor

Meet the manifest.

The RSRM Project successfully supported seven Shuttle flights with no IFAs. This supports the metric of maintaining less than one IFA per mission.

The RSRM Project continued its superior performance in support of the SSP manifest. On time launches were achieved with no delays attributable to the RSRM Project. The RSRM Project also took a proactive approach by performing Process Failure Modes and Effects Analyses to assure good process control and robustness of processes related to solid rocket motor manufacturing and refurbishment.

Safety.

Safety continues to be the principal focus in the manufacture of the SSP's RSRM. This is reflected in the job-related accident frequency rates at ATK Thiokol Propulsion, which have been well below the rates of similar industries as published by the BLS. In fact, the company's record in CY 2000 for Occupational Safety and Health Administration (OSHA) recordable and lost workday injury rates were at record lows for the past several years. ATK Thiokol reached the following significant safety milestones this past year:

- The test area surpassed 4.3 million hours, or 12.5 years, without a lost-time accident.
- The Nozzle Work Center surpassed 2.1 million hours, or 6.7 years, without a lost-time accident.

Workforce safety continues to be a major area of emphasis for the RSRM Project. Monthly area walk-throughs were conducted and results were documented. The RSRM Project implemented a plan/schedule involving all personnel in the scheduled monthly walk-throughs. Involvement of all personnel assures their understanding of the importance of the safety program at MSFC. In addition to monthly safety walk-throughs, each weekly staff meeting begins with a safety moment, which is presented by RSRM personnel.

Enhancing safety, assuring Mission Supportability, and sustaining the life of the Space Shuttle are all major objectives of the RSRM Project. The RSRM Propellant Grain Geometry Modification Project was initiated to increase structural margins, thus improving the safety of the SSP. Through extensive testing and analysis, it has been determined that adequate margins of safety exist in the current configuration, thus eliminating the need for modifications.

Safety performance at the RSRM prime contractor facilities (Utah) continued to exceed industry standards. Two evaluation periods' (Buy 4 periods 3 and 4) reports reflected lost time rates and OSHA recordable rates significantly lower than industry averages.

Solid Rocket Booster.

Maintain less than one in-flight anomaly per mission.

SRB exceeded this metric—seven flights and one IFA (.14 IFAs/mission)

Work Force Safety: Conduct the following safety initiatives to ensure a safe workplace environment:

- *Monthly area walk-throughs and documentation.*
- *Monthly project safety meetings.*

Both the SRB Project Office and our prime contractor, USA/SRB, have met this metric.

Maintain safety performance records at our contractor facilities that exceed industry standards.

FY 2001 lost-time incident rate was 0.0 compared to 0.6 for the guided missile industry.

Enhance safety, assure mission supportability, and sustain the life of the Shuttle.

To improve the reliability of the Space Shuttle, propulsion system upgrades such as SRB Advanced Thrust Vector Control (ATVC) are to be incorporated. The project successfully completed the PRR and the combined SRR/SDR for the ATVC.

Meet the manifest and improve mission supportability.

Meet the manifest and improve mission supportability through: Robust processes, process control, production process efficiency, and ontime launches with no delays attributable to the MSFC propulsion elements.

SRB supported the manifest and had no launch delays. The project improves mission supportability via weekly and quarterly project reviews, independent assessment teams, NASA Engineering and Quality Audit, and vendor quality and motivational visits.

Space Launch Initiative

The Space Launch Initiative (SLI) is at the heart of NASA's broad-based Integrated Science Transportation Plan, which also includes Space Shuttle safety upgrades to keep America's 1st Generation Reusable Launch Vehicle (RLV) flying until the 2nd Generation vehicle is operational as well as futuristic research for potential transportation systems in the decades to come. The MSFC-led SLI is NASA's top new development program aimed at enabling significant near-term improvements in America's space capabilities.

The fundamental work funded by the SLI is the initial phase required to lay realistic plans for the full-scale development and flight phase to follow. In its two-fold approach, the SLI is designing complete space transportation systems that can fulfill basic civil and defense mission requirements while developing the technologies needed to build and operate the system finally chosen for full-scale development.

To ensure success, NASA has brought together some of the Nation's most talented scientists and engineers, while making available its extensive research, test, development, and evaluation facilities, some of which are one of a kind. Comprehensive top-to-bottom systems engineering and the cost-control process ensure that the Government gets what it pays for by measuring technical progress against the schedule at regular intervals. The cost-to-benefit ratio must prove a wise investment; gated procurements provide built-in "off ramps" to discontinue efforts after a period of performance, as well as "starting gates" to add new tasks to fill technology gaps and spur competition. The research funded must be directly relevant to SLI goals to reduce the technical and business risk of developing a new RLV system.

Through teamwork with its partners in the U.S. aerospace industry, academia, and the military complex, NASA contributes its experience in space transportation systems research and development to enable a new generation of space transportation capabilities for a stronger America.

A primary mission for the 2nd Generation RLV will be servicing the *International Space Station*.

FY 2001 Space Launch Initiative Metrics and Performance

Complete X–40A approach and landing test series.

The X–37 Project has completed a highly successful series of seven tests of the X–40A, a suborbital prototype of the X–37 technology demonstrator vehicle. These tests contributed valuable data needed to complete the X–37 design and are part of a growing RLV knowledge base.

Complete X–37 design.

Although the X–37 Project was not selected for initial funding under the 2nd Generation RLV NASA Research Announcement (NRA) 8–30, the descoped effort continues under the original cooperative agreement between Boeing and NASA. The X–37 technology demonstrator vehicle design was completed, and construction completion is anticipated in 2003.

Complete X–34 captive-carry testing.

The X–34 technology demonstrator vehicle captive-carry tests were successfully completed in July 2000.

Conduct initial, unpowered flight of X–34.

The X–34 Project was begun in 1996, prior to the advent of SLI. The X–34 Project was required to compete for additional funding as part of the 2nd Generation RLV NRA 8–30 procurement process. When evaluated against other proposals, NASA determined that the benefits did not justify the additional investment and the project was terminated in March 2001.

Complete initial X–34 unlined composite lox tank test series.

The X–34 Project was terminated before this series of tests was completed. However, work completed before that time has been added to the knowledge base of graphite-epoxy structures.

Conduct integrated X–34 propulsion testing with MC–1 engine.

The MC–1 engine development was successfully completed. The X–34 Project was terminated prior to the integrated propulsion testing.

Conduct postflight analysis of SHARP–B2 flight experiment.

The SHARP–B2 flight was successfully conducted, and the postflight experiment analysis has been completed.

Complete competitive solicitations and award multiple industry contracts for 2nd Generation RLV requirements definition and risk reduction effort.

In May 2001, approximately $790 million in SLI requirements definition and risk reduction contracts were awarded to begin a nationwide effort to design a viable 2nd Generation RLV backed up by the technologies to build and operate the new space transportation system. Architecture contracts are focused on designs that meet mission requirements, as well as safety, reliability, and cost goals. Focused technology investments are empowering new capabilities for civil science and breakthrough exploration while promoting commercial interests and national security.

Complete and review results of Alternate Access to Station study contracts; release follow-on Request for Proposals.

The Alternate Access to Station study reports were evaluated by an inter-Center NASA team led by the MSFC. Initial results were briefed to NASA HQ in April 2001, with several follow-on reviews. The Concept Definition Request for Offer was released on November 11, 2001. Proposals were received in February 2002 and have been reviewed.

Complete dual engine testing for X–33 flight engines.

The X–33 Project was begun in 1996, prior to the advent of the SLI. The X–33 Project was required to compete for additional funding as part of the 2nd Generation RLV NRA 8–30 procurement process. When evaluated against other proposals, NASA determined that the benefits did not justify the additional investment and the cooperative agreement between NASA and Lockheed Martin was allowed to expire in March 2001. Since the prototype linear aerospike engines were in the test stand, they were used as a test-bed for an SLI risk-reduction project to develop electromechanical actuators, a potentially significant improvement over hydraulic actuators.

Complete design of X–33 metallic LH_2 tanks.

All X–33 design and test efforts on metallic tanks ended when the cooperative agreement between NASA and Lockheed Martin was allowed to expire in March 2001.

Advanced Space Transportation Technology

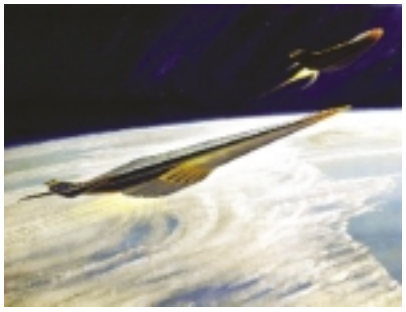
The Advanced Space Transportation Program (ASTP) at MSFC looks beyond second generation systems, developing technologies needed to fly a Third Generation RLV by 2025, and a Fourth Generation RLV by 2040. The Third Generation RLV is expected to make launches 1,000 times safer and 100 times cheaper than today. The Fourth Generation RLV is expected to improve safety and reduce cost by yet another order of magnitude, making space travel virtually indistinguishable from modern air travel—10,000 times safer and 1,000 times cheaper than today's rockets. Advanced in-space propulsion technologies will enable missions to new destinations and/or increase performance and return for a variety of space missions.

Reaching these goals requires revolutionary aerospace technologies—from magnetic, chemical, and propellantless propulsion systems to all-new energy sources, such as space solar power or antimatter propulsion. These and other advances are now being studied, developed, and tested at MSFC's Propulsion Research Center, as well as other NASA field Centers and partner institutions all over the nation.

Innovative material and process technologies are also under investigation as NASA and its partners seek ways to develop safer, stronger, and more durable engines, vehicles, structures, and components that will handle the immense power of these futuristic propulsion systems.

Hypersonics Program Development

Building on the synergy between space and aeronautics programs seeking hypersonic flight capabilities—sustained air travel at more than six times the speed of sound—the MSFC, in 2001, launched an aggressive effort to enable a new generation of air-breathing, combined-cycle rocket engines. Spacecraft powered by such engines would be completely reusable, able to take off and land at airport runways, and ready to fly again within days.



2-stage airbreather launch concept.

Working closely with the U.S. Department of Defense (DOD), NASA will commit $800 million over the next 5 years to develop hypersonic technologies. Its approach initially calls for incremental ground and flight tests focusing on hypersonic propulsion and airframe technologies that are to be integrated with additional technology requirements as development progresses over the next 15–18 years. In 2001, the Deputy Undersecretary of Defense for Science and Technology chartered a joint DOD/NASA National Aerospace Initiative. This effort is focused on transformational technologies in hypersonics and access to space.

Integrated Systems Test of an Air-breathing Rocket

A goal of NASA's Aerospace Technology Enterprise is to utilize the full potential of space for all human endeavors through safe, affordable, and reliable space transportation. As part of the Hypersonic Investment Area under NASA's ASTP, the goal of the Rocket-Based Combined Cycle (RBCC) Project is to demonstrate the potential of an engine system to reduce launch costs and increase reliability. This Integrated Systems Test of an Air-breathing Rocket (ISTAR) will be accomplished by developing an engine system capable of accelerating a self-powered vehicle from Mach 0.7 to scramjet takeover at approximately Mach 7. The ISTAR Project will work with a consortium of U.S. rocket engine development companies to design and fabricate an RBCC engine for testing. The RBCC/ISTAR Project and consortium seek to fully utilize the full range of capabilities, facilities, hardware, and technologies that are available within the domestic rocket and air-breathing propulsion industry to obtain the optimal product from the standpoint of cost and quality.

In December 2001, the MSFC took a major step toward realizing its hypersonic goals, awarding the ISTAR design contract to the RBCC Consortium industry team that seeks to develop a ground-test version of an RBCC rocket engine by 2007.

In-space Transportation

NASA will develop a portfolio of new in-space transportation technologies over the next several years, with the goals of enabling spacecraft to reach new destinations, reducing trip time, and increasing the payload mass delivered. In 2001, a team of more than 100 technologists and mission analysts from across the Agency, working with NASA Enterprise customers, developed an Integrated In-Space Transportation Plan (ISTP) containing a prioritized list of in-space propulsion technologies capable of meeting NASA's science and exploration goals. From the next generation of electric propulsion to solar sails and aerocapture, NASA will competitively select technology based on ISTP priorities to meet these goals from our industry, university, and Government partners via open solicitations.

Propulsive Small Expendable Deployer System

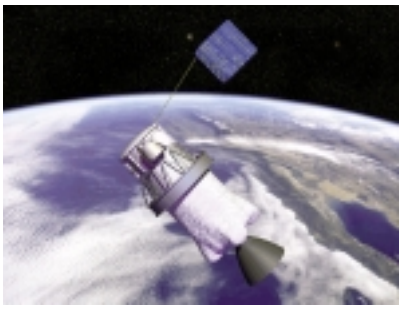
Preparations continued at the MSFC in 2001 for the first in-space demonstration of an electrodynamic tether-based propulsion system. Now scheduled for launch in late 2002 or early 2003, the Propulsive Small Expendable Deployer System (ProSEDS) is a secondary payload on a Delta II U.S. Air Force Global Positioning System (GPS) mission. As a secondary payload, the experiment is dependent on the U.S. Air Force GPS launch schedule.

Inexpensive and reusable, ProSEDS technology has the potential to turn orbiting, in-space tethers into space tugboats, thereby replacing heavy, costly, traditional chemical propulsion and enabling a variety of space-based missions such as the fuel-free raising and lowering of satellite orbits. System and component testing of ProSEDS flight hardware was conducted throughout 2001 and is to be completed in 2002.

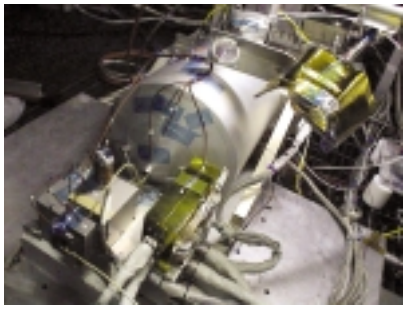
Propulsion Research Laboratory

Missions to the outer solar system—and eventually to other stars—will require performance well beyond even those capabilities needed for interplanetary flight. In late 2001, NASA's Propulsion Research Center, a national resource housed at the MSFC for advanced propulsion research, completed an environmental assessment for its new multimillion dollar, state-of-the-art Propulsion Research Laboratory (PRL), which begins construction in 2002. The 66,000-square-foot laboratory will be housed at a 21-acre site on Redstone Arsenal. Construction is planned for completion in early 2004.

Once the facility is completed, scientists and engineers from NASA, industry, academia, and the U.S. Departments of Energy and Defense will pool their resources and expertise onsite. They will perform landmark propulsion research that will set the stage for a broad range of revolutionary space flight applications. Research and subscale experiments will be conducted in a number of areas, including advanced chemical propulsion, propulsion energetics, solar propulsion, electromagnetic propulsion, propellantless propulsion, and high pressure combustion research.



An artist's concept of NASA's Propulsive Small Expendable Deployer System (ProSEDS) as the tether is deployed in space.



Propulsive Small Expendable Deployer System (ProSEDS).

Artist rendering of the Propulsion Research Laboratory.

FY 2001 Advanced Space Transportation Technology Metrics and Performance

The following FY 2001 metrics are based on planned performance expectations published in December 2000 as part of the MSFC's FY 2001 Implementation Plan.

Fly ProSEDS tether-propulsion flight experiment.

The ProSEDS tether-propulsion flight experiment was scheduled to fly in April 2001 as a secondary payload on a Delta-II GPS replacement mission. Due to a delay of the scheduled mission, the ProSEDS launch date was rescheduled. Although still subject to the Air Force's launch schedule, ProSEDS is currently scheduled for launch in July 2002.

Complete Propulsion Research Laboratory engineering study and initiate Propulsion Research Laboratory design effort.

The PRL engineering study—establishing site selection, design concept, and criteria to be used as a baseline for the detailed PRL design—was completed in December 2000 and awarded to Bechtel National, Inc. Study results also served as a basis for the facility cost estimate necessary for budgetary planning. The detailed design contract was awarded to Jacobs Sverdrup in May 2001. The detailed PRL design was scheduled for completion in April 2002.

Complete X–38 deorbit propulsion system hardware integration.

Delayed by *International Space Station* (*ISS*) funding and development problems, the X–38 deorbit propulsion system hardware was delivered in CY 2001 to Johnson Space Center.

Validation of polymer matrix composite cryogenic LH_2 and LOX tanks.

Completed validation of polymer matrix composite cryogenic LH_2 and lox tanks, including:

- Compatible materials systems and processes.
- Fabrication and joining technology for large-scale articles.
- Demonstrated thermal performance.

Complete Systems Requirements Review for Rocket-Based Combined Cycle demonstrator engine.

The RBCC/ISTAR Project team met a level-1 milestone in 2001 with completion of a successful CDR at Rocketdyne's Canoga Park, CA, facility. Following that design review, the SRR has been rescheduled for June 2002.

Release Request for Proposals, perform evaluations, and negotiate contract for Next Generation Learning System.

Based on comments received from industry to the draft Next Generation Learning System (NGLS) Request for Proposals (RFP) and the lack of compliant responses to the final RFP released in January 2001, the market volatility has significantly affected initial acquisition assumptions. Accordingly, the approach pursued under the NGLS acquisition is no longer viable and the Office of Space Flight has withdrawn the requirement to further pursue NGLS acquisition.

Microgravity

Microgravity Research Program

The Microgravity Research Program Office (MRPO) continued to successfully administer NASA's space research efforts to support the human exploration of space and take advantage of the space environment as a laboratory for scientific, technological, and commercial research. Commercial program efforts were administered through the Space Product Development (SPD) Office, and NASA's research on the effects of gravity in chemical, physical, and biological systems were administered through the Microgravity Research Program (MRP).

The Office of Biological and Physical Research (OBPR) Enterprise was launched in October 2000 to establish the core of biological and physical sciences research needed to support Agency strategic objectives, to foster commercial development in space, and to ensure an effective management structure to optimize the implementation of the Agency's scientific and technological goals. MRPO assisted OBPR in the initiation of efforts to establish interdisciplinary research linking the biological and physical sciences, to define technology development activities linking OBPR with other Agency enterprises, and to initiate the significant activity of reprioritizing *International Space Station* (*ISS*) research activities post-FY 2004.

Four space-infrastructure-focused commercial space centers were transferred from the Office of Aerospace Technology to OBPR for management by MRPO's SPD Office, bringing the total number of commercial space centers (CSCs) to 15.

The Educational Outreach activities continued to inform the public and inspire youth toward careers in math, science, and technology by communicating how OBPR's unique space research benefits life on earth and advances the capability of long-duration human exploration.

Space Product Development Commercial Highlights

A consortium that focuses on biomaterials—implants and other materials designed to be used with living tissue—has been established by the Center for Commercial Applications of Combustion in Space (CCACS) and BioServe Space Technologies. This consortium builds on the advanced biomedical materials development work at CCACS and the advanced biotechnology research at BioServe. Industry partners are anchored by Hewlett-Packard Company and Sulzer Medica Ltd. More partners are being recruited for this effort, which has the potential to revolutionize the production of biomedical implants.

Two potential anticancer compounds from BioServe Space Technologies were optioned for licensing by AnorMed, Inc. of Vancouver, Canada. These compounds, developed at BioServe's Kansas State University location, have been found to exhibit inhibitory properties against cancer. AnorMed hopes to further develop the compounds into anticancer therapeutics for future clinical studies.

The Center for Biophysical Sciences and Engineering (CBSE) has been chosen as one of the National Institutes of Health's (NIH's) seven national centers for high-throughput structural proteomics. The purpose of NIH's commitment is to support the development of new technologies in molecular biology and high-throughput crystallography. These capabilities, combined with the completion of the human genome sequence and the genomes for dozens of bacteria, viruses, and other species, make it possible for the CBSE to consider the determination of the three-dimensional protein structures of entire genomes. This information will provide a powerful capability for understanding functions of these biological molecules and provide key information for the development of new pharmaceuticals for chronic and infectious diseases.

ProVision Technologies' food quality and safety program, with Sanderson Farms and the U.S. Department of Agriculture, has developed algorithms that can detect contaminated chickens on the processing line while the birds are moving at the operational plant speed of 70 birds per minute. If incorporated into future chicken processing equipment, this could help increase food safety by easily identifying and removing contaminated chickens.

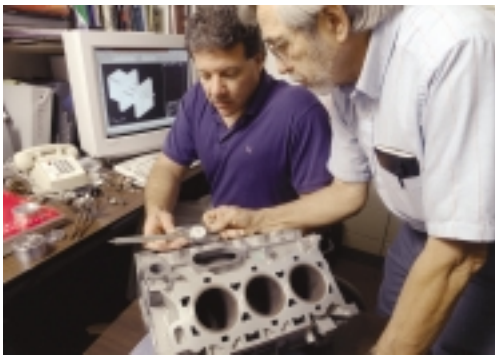
Collaboration between the Center for Space Power and Advanced Electronics and the Center for Microfibrous Materials at Auburn University has led to the production

of nickel-carbon supercapacitor electrodes, which were made using a semiautomated papermaking facility. These composite electrodes are the first in the marketplace and have been used by Industry Partner Eagle Picher LLC of Joplin, Missouri, in 30V, 5-Farad, space-rated supercapacitors. Supercapacitors are being examined by a number of companies and NASA, for use in applications with high-peak power requirements, such as high-reliability electromechanical actuator systems and hybrid-electric vehicle drive systems.

The Federal Bureau of Investigation (FBI) and ProVision Technologies conducted a pilot study to determine the utility of hyperspectral imaging for differentiating ink types. Encouraging results indicate the potential for using this technology to detect altered documents, counterfeit money, and forged passports. An expanded program will occur in 2002. Funds and technical support will be supplied by the FBI. ProVision Technologies will place an employee and a hyperspectral sensor at the FBI Academy in Quantico, Virginia to conduct this work.

Industry researchers affiliated with the Consortium for Materials Development in Space have determined the crystal structure for human protein tyrosine phosphatase (PTP) sigma. This protein is found in a variety of human tissues, including bone, brain, and lung, as well as in osteosarcoma, a bone cell cancer. Mapping the structure of PTPs provides an important target for new drug design since inhibiting this protein may help fight bone diseases ranging from osteoporosis to bone cancer.

Work by the Solidification Design Center (SDC) with General Motors Powertrain will result in shorter development time for complex metal castings. Using software called ARENA^{TM}, developed by industry partner Flow Simulation Services, the SDC was able to accurately simulate the complex process of producing the cores and molds needed for such parts. This will eliminate the traditional trial-and-error process for making cores and molds, allowing a reduction in development time and improvements to product quality.



Space Product Development has led to improved metal castings.

FY 2001 Microgravity Space Product Development Metrics and Performance

Provide leadership and support to ensure that all Space Product Development payloads meet ground and flight safety requirements.

All SPD payloads met ground and flight safety requirements.

Provide policies and resources to enable at least 50 undergraduate and graduate students to participate in commercial spaceflight and technologies research.

Over 60 undergraduate and graduate students participated in commercial spaceflight and technologies research through the CSC Program.

Provide policies and resources to enable at least 10 new active industrial partnerships to be established with the Space Product Development commercial space centers.

Over 12 new active industrial partnerships were established, including companies such as DuPont and Pioneer Hi-bred International, Inc.

Initiate review of all Space Product Development commercial space centers using criteria based on established policies and operating principles.

Statement of work for review team was approved late in FY 2001, enabling the review to begin in 2002.

Review the Annual Report, recommend and implement additions or changes for FY 2001 Report.

The Annual Report has been reviewed and the 2001 Annual Report has been modified.

Support at least four industrial conferences with Space Product Development displays and information booths.

Four industrial conferences were supported, which included National Manufacturing Week, American Ceramics Society, American Casting Congress, and the Biotechnology Industry Organization conference.

Microgravity Research Program

As the Lead Center for Microgravity Research for OBPR, the MRPO provides programmatic direction for the MRP through three NASA Centers—Marshall Space Flight Center (MSFC), Glenn Research Center (GRC), and Johnson Space Center (JSC)—and the Jet Propulsion Laboratory, which conduct research in five scientific disciplines: fluid physics, combustion science, fundamental physics, biotechnology (cellular and macromolecular), and materials science.

The MRP administered and funded 553 research investigations representing 41 states that worked on peer-reviewed flight research and related ground-based projects. These projects have consistently made contributions to the understanding of biological and physical processes in space. In FY 2001, 669 scientific articles were published in peer-reviewed journals, and 15 patent applications were submitted. Twenty-five microgravity research payloads were successfully integrated and sent to the *ISS* for low gravity space research.

The Microgravity Research Educational Outreach responsibilities were expanded to encompass both life science and microgravity research. Consistent with this joint responsibility, the *Microgravity News* quarterly newsletter was changed to *Space Research* and expanded to include articles and events of all OBPR space research. Other educational outreach activities include publishing two education guides targeting middle school students, adding significant microgravity content in the 2002 edition of the middle-high school technology textbook "Technology in Action," conducting two educator peer-review workshops, and providing support to numerous other outreach events.

Space research continued on both the *ISS* and Space Shuttle. Three microgravity and three commercial research investigations were launched to *ISS*. Two combustion science investigations and one fluid physics investigation conducted research on the Space Shuttle.

MRP also continued to provide terrestrially-based microgravity access by providing for 10 parabolic aircraft flights and access to short-duration microgravity available in the program's drop towers. The MRP continued to pursue ground-based research in biotechnology, materials science, fluid physics, combustion processes, and diverse areas of fundamental physics through grants and hardware developments funded by the OBPR.

Microgravity Research Science Highlights

From conducting investigations in space to supporting ground-based and technology investigations, microgravity research continues to provide exciting fundamental research results. Several of the top research findings are highlighted below.

Fluid Physics

NASA GRC manages and executes fluid physics space research for the MRP. Fluid physics encompasses a wide range of physics and engineering science research, including studies of heat and mass transfer processes, fluid dynamics, and the physics of complex fluids. The goal of much of fluid physics research is simply to comprehend fundamental physical phenomena.

The Physics of Colloids in Space (PCS) fluid physics investigation was activated in June 2001 in an Expedite the Processing of Experiments to the Space Station (EXPRESS) Rack on the *ISS*. The investigation will remain until May 2002, and is gathering data on the basic physical properties of colloids by concurrently studying three different types of colloids with the objectives of understanding how colloidal structures grow, the rates at which they grow, and the structures that they form. This information is useful for gaining insight into the basic nature of liquid-to-solid phase transitions, for better understanding how colloidal constituent properties affect the properties of the bulk colloidal suspension, and for beginning to probe the unique light scattering properties of nano-engineered binary colloidal alloys. The potential payoffs of PCS are: improvements in the properties of paints, ceramics, and food and drug delivery products; decreased product development time and more efficient production of products having colloidal suspensions as precursors; and possibly the development of an entirely new class of materials which can passively affect the properties of light passing through them. In the latter case, such materials may find uses as optical switches and lasers for advanced communications and displays. Industries using semiconductors, electro-optics, ceramics, and composites are among those that may benefit from colloid research. The experiment focuses on the growth and behavior of three different classes of colloid mixtures of tiny manmade particles of either polymethyl methacrylate, silica, or polystyrene; the samples being studied include binary colloidal crystal alloys, colloid-polymer mixtures and

fractal aggregates. PCS is being remotely operated from the GRC's Telescience Support Center in Cleveland, OH, and at an established remote site at Harvard University in Cambridge, MA.

The photographs below are of an example of an AB6 binary sample homogenized on June 29, 2001. The left image is of the premixed sample. The middle image shows the same sample after 1 hour and 18 minutes. Some crystallization is already evident. The right image was taken at the end of the run, 20 days, 11 hours, 18 minutes after the sample was mixed. Crystallization is most evident along the edges of the sample. The samples are lit with white light to produce these images. The colloidal crystals affect the properties of the light passing through them, sometimes producing a colorful spectrum.

Combustion science

NASA GRC manages and executes combustion science space research for the MRP. Combustion science space research includes investigations of a wide range of fundamental combustion processes, development of rational design procedures for maximizing efficiency and minimizing pollution associated with combustion processes on Earth, development of novel methods for materials production via combustion, improvement of fire safety at reduced gravity conditions, and development of combustion-related technologies that will aid human exploration of space.

Microgravity researchers have been attempting to better understand how materials burn in space and what can be done to ensure the safety of astronauts. With the *ISS* nearing completion, the possibility of fires harming astronauts or causing millions of dollars of damage to equipment is an increasing worry. Researchers at the Microgravity Combustion Laboratory at the University of California, Berkeley and GRC have conducted investigations aboard the Shuttle to examine smolder processes in normal gravity and in the apparent weightlessness of microgravity. The microgravity setting is especially valuable because it permits scientists to study smoldering combustion processes without the obscuring effects of gravity.

The Microgravity Shuttle Combustion (MSC) experiment that flew aboard STS–105 in August 2001 tested smoldering combustion in two different air-flow conditions—one forward and one opposed. New imaging technology was used to record test results. The MSC experiment flew again aboard STS–108 in December 2001 and tested smoldering combustion in two configurations—quiescent and forward flow. Smoldering combustion is a complex, non-flaming form of burning that occurs in the interior of porous, combustible materials. These materials can be natural—piles of leaves and pine needles—or man-made—furniture stuffing and cable insulation.

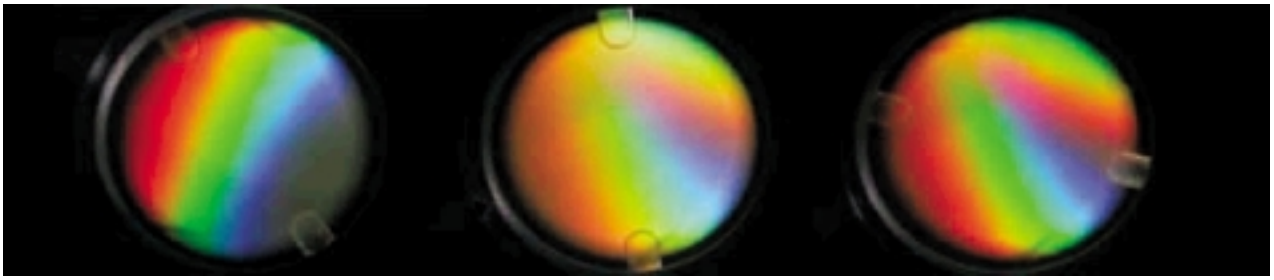
Cross section of smoldering foam.

The results of this experiment will help scientists more fully understand the complex processes of smoldering combustion. This knowledge will lead to a better theoretical computer model of the mechanisms of smoldering combustion and this, in turn, will be applied to developing safer products for use on Earth and in space.

The Spread Across Liquid (SAL) experiment was launched aboard a suborbital sounding rocket from White Sands, NM, in February 2001 on its sixth research mission. The objective of the SAL–6 experiment was to study the burning characteristics of liquid fuel in a microgravity environment.

Fundamental physics

The Jet Propulsion Laboratory manages and executes fundamental physics space research for the MRP. Fundamental physics space research investigates the basic laws that govern the properties of the physical world on all scales, from microscopic to cosmic. The primary focus is on acquiring new knowledge about our world and



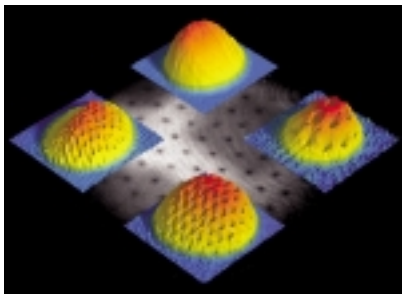
universe. The microgravity environment improves fundamental physics research because investigations can yield entirely new or substantially improved results when the obscuring effects of Earth's gravity are not present. The areas of interest are gravitational and relativistic physics, laser cooling and atomic physics, low-temperature and condensed-matter physics, and biological physics.

By spinning ultra-cold sodium gas in a laboratory, NASA-funded scientists at the Massachusetts Institute of Technology (MIT) in Cambridge have created a gas cloud that resembles rounded Swiss cheese and is riddled with tiny whirlpools, like those that cause "starquakes" in space. This research may teach scientists more about the history of our universe and the stars within it and may eventually lead to vast improvements in highly precise atomic clocks. The laboratory demonstration is related to puzzling glitches observed by astronomers in the otherwise smooth, rapid rotation of pulsars. A pulsar is a type of neutron star, a remnant of a dying star and one of the densest objects in the universe. Glitches in pulsar rotation are called "starquakes" and may occur when whirlpools, or vortices, form or decay.

Professor Wolfgang Ketterle, the MIT physics professor who led the research team, and his colleagues cooled the sodium gas to less than one millionth of a degree above absolute zero (–273ºC or –460ºF). At such extreme cold, the gas cloud converts to a peculiar form of matter called Bose-Einstein Condensate (BEC), as predicted 75 years ago by Dr. Albert Einstein. In October 2001, Professor Ketterle was one of three physicists awarded the Nobel Prize in Physics for his findings in BEC.

Fundamental physics researchers, led by Randall Hulet at Rice University in Houston, TX, successfully simulated and photographed the process by which white dwarfs and neutron stars retain their size and shape, a mechanism called Fermi pressure. White dwarfs and neutron stars are dense, compact objects created when normal stars use up their fuel, cool, and succumb to the forces of gravity.

Fermi pressure, named for Dr. Enrico Fermi, a Nobel Laureate prominent for his contributions in nuclear physics, has been theorized as the star stabilization mechanism that keeps white dwarfs and neutron stars from collapsing further. NASA's Hubble Space Telescope and Chandra X-ray Observatory have observed such objects, but this is the first time Fermi pressure has been directly observed in an Earth-based laboratory.



The image above depicts the formation of multiple whirlpools in a sodium gas cloud. This process is similar to a phenomenon called "starquakes" that appear as glitches in the rotation of pulsars in space.

Biotechnology

Biotechnology space research consists of both cellular biotechnology and macromolecular biotechnology. JSC manages and executes cellular biotechnology space research, and MSFC manages and executes macromolecular biotechnology for the MRP.

Cellular biotechnology

The cellular biotechnology element uses NASA cell culture technology and the microgravity environment of space to advance ground-breaking research in biomedical science. The element emphasizes four areas of research: 1) tissue engineering for research, transplantation, and biopharmaceutical production, 2) tissue production for disease modeling such as cancer, 3) vaccine production through propagation of microorganisms, and 4) space cell biology as it relates to the transition of terrestrial life to low-gravity environments and to the exploration of space.

NASA's biotechnology cell science research aboard the *ISS* is intended to provide controlled cultivation of cells into healthy, three-dimensional tissues that retain the form and function of natural, living tissue. Studying normal growth and replication of human cell tissue outside of living organisms is difficult because most cells cultivated outside the body form flat, thin specimens that limit insight into the way cells work together. However, cells grown in microgravity—the low-gravity environment inside spacecraft orbiting the Earth—much more closely resemble those found in our bodies here on Earth.

Bioreactor-based cell growth in microgravity permits cultivation of in vitro tissue cultures of sizes and quality not possible on Earth. Such a capability provides unprecedented opportunities for breakthrough research in the study of human diseases, including various types of cancer and heart disease.

During FY 2001, several experiments were delivered to the *ISS* for the study of human diseases such as cancer. These included studies in the human immune system, molecular genetic expression, and the ability for human cells to be manipulated in microgravity. There is significant evidence that the microgravity environment contributes in some manner to changes in cell growth. Data from these experiments will improve our knowledge of effects of microgravity on the body's systems and suggest possible in-flight countermeasures as well as treatments for ground-based diseases.

Macromolecular biotechnology

Macromolecular biotechnology space research includes a basic science component and an applied science component. The basic science component seeks to understand the fundamental physics and chemistry of macromolecular crystal growth by utilizing the microgravity environment to study aspects of the crystal growth process that are masked by gravity on Earth. The applied science component of the program uses the microgravity environment to produce higher quality crystals that are subsequently used in ground research to produce more detailed and more accurate atomic structures of macromolecules. Examples in this element include structural biology research, biological nanotechnology, and biomolecular self-assembling materials.

During FY 2001, significant research in this area continued to be conducted aboard the *ISS*. A detailed report of this effort is provided in the Microgravity Science and Applications section.

Materials science

MSFC manages and executes materials science space research for the MRP. The materials science element includes research in a broad range of areas that can be categorized in terms of the class-like behavior of materials, including electronic and photonic materials, glasses and ceramics, metals and alloys, and polymers and nonlinear optical materials. Research areas specific to space exploration included radiation shielding that is appropriate for long-duration lunar or Mars missions and the effects of gravity on the materials processes necessary to convert resources found on other bodies of the solar system into usable commodities.

Significant progress continued to be made regarding the quantitative and predictive relationships between the structure, processing, and properties of materials; however, budget cuts resulted in delays for space-based research. A detailed report of the effort is provided in the Microgravity Science and Applications section.

Tissue Culture Module (TCM) used to grow human cells on *ISS*.

FY 2001 Microgravity Research Program Metrics and Performance

Support at least 450 investigations.

The MRP exceeded its metric to support at least 450 investigations by supporting 553 research investigations.

Support at least 10 Science Concept Reviews and 15 Requirements Definition Reviews.

The metric to support at least 10 Science Concept Reviews (SCRs) and 15 Requirements Definition Reviews (RDRs) was impacted by reductions in *ISS* space research funding. The reductions caused delays in flight schedules and reduced the ability to do perform definition work; therefore, only eight SCRs and six RDRs were held.

Conduct research on at least 12 KC–135 flight campaigns to produce selected science and engineering data.

The program conducted 11 KC–135 flight campaigns to produce selected science and engineering data against a metric of 12. A campaign scheduled in September 2001 was delayed due to aircraft flights being grounded as a result of the September 11th national tragedy.

Conduct two suborbital sounding rocket flights.

Two suborbital sounding rocket flights were planned. The SAL-6 mission was launched in February 2001 aboard a sounding rocket. However, Research and Technology funding was diverted to aid in shortfalls in the *ISS* research, causing funding for the second flight of the Extensional Rheology Experiment to be cancelled.

Conduct goal-directed workshop to define methods, databases, and validating tests for material flammability characterization, hazard reduction, and fire detection/suppression strategies for spacecraft and extraterrestrial habitats.

In June 2001, a focused workshop on Research Needs in Fire Safety for the Human Exploration and Utilization of Space was held in Cleveland, OH, to address problems and solutions to materials and processes needed to assure spacecraft and extraterrestrial habitat safety issues. With this meeting, MRP met the metric to conduct a goal-directed workshop to define methods, databases, and validating lists for material flammability characterization, hazard reduction, and the detection/suppression strategies for spacecraft and extraterrestrial habitats.

Conduct biotechnology, fluid physics, and small multidiscipline investigations on the ISS according to the U.S. Partner Utilization Plan.

MRP integrated and flew 25 microgravity space research payloads on six flights to the *ISS*. These missions conducted research in biotechnology, fluid physics, and small multidiscipline investigations such as acceleration measurement. Therefore, the metric to conduct biotechnology, fluid physics, and small multidiscipline investigations on the *ISS* according to the U.S. Partner Utilization Plan was met.

Use the rotating bioreactor to model microgravity for microbes and mammalian cells to identify potential parameters.

Cellular biotechnology research investigations were conducted on the *ISS* using the rotating bioreactor hardware to identify parameters in microbes and mammalian cells and to aid in identifying cells of best nature for future space flight experiments. This effort met the MRP metric to use the rotating bioreactor to model microgravity for microbes and mammalian cells to identify potential parameters.

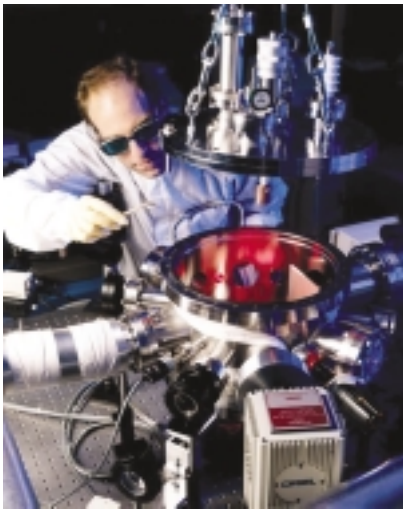
Microgravity Science and Applications

Introduction

The Microgravity Science and Applications Department (MSAD) within the Science Directorate at MSFC is responsible for implementing the Materials Science, Macromolecular Biotechnology, and Glovebox Programs for NASA. To implement the programs, the MSFC has a unique team of scientists, engineers, and managers teamed with industry, academia, and international individuals and organizations to establish, perform, and maintain world-class research in those fields. MSAD is also responsible for providing Glovebox facilities on the Shuttle and *ISS* for the purpose of supporting low-cost and fast-track investigations from all disciplines of the NASA Microgravity Program. MSAD is responsible for the financial and managerial administration of all selected Materials Science and Macromolecular Biotechnology investigations, assistance in the definition of focused science objectives, access to ground and flight facilities and carriers, definition and development of new enabling research technology, definition and development of scientific apparatus and facilities, mission operations support, and transfer of the accumulated microgravity database.

Materials Science

FY 2001 was a busy year for the Materials Science discipline. NASA Research Announcement (NRA) NRA–01–OBPR–05, *Materials Science: Ground-based Research Opportunities in Biomaterials and Radiation Shielding* was released. Budget cuts to the program resulted in significant losses of peer-reviewed science. While all four of the projected SCRs were held, none of the intended six RDRs occurred, and other investigations were indefinitely delayed or deleted altogether. Deletions include flight investigations, two automated research racks, and all of the NASA Experiment Module and Module Inserts planned for research aboard the *ISS*. Only a limited version of the initial rack for materials science research remains in the program. Still, the discipline continued to be highly productive, and includes Principal Investigators (PIs) that share a common steadfast interest in materials science research. The first Materials Science Research Rack (MSRR–1) made considerable progress toward its Integrated Payload Critical Design Review. The MSRR–1 team participated in the Materials Science Lab Crew Station Review in Europe.



The ground-based Electrostatic Levitator (ESL) continued to provide PIs with insight into the thermophysical properties of materials.

Fabrication of a full-scale mockup of MSRR–1 was completed. This high-fidelity mockup, designed for outreach and education, can be easily upgraded to support crew training. The mockup can be used as a stand-alone display or integrated into a full-scale mockup of the U.S. Space Lab Module Destiny.

Full-scale MSRR–1 Mockup.

Ground testing of the Quench Module Insert continued. The breadboard unit was built and is currently being tested to verify the design concept.

Milestones were reached in the production of Sample Ampoule Cartridge Assemblies (SACAs). SACA is a safe, self-contained, ampoule for material samples being studied.

The Payload Equipment Restraint System (PERS) was deployed to the *ISS*. In use on-orbit 24 hours a day, 7 days a week, the PERS quickly became the most popular gear for the *ISS* crew.

Successful testing of the Bridgman Unidirectional Dendrite in Liquids Experiment (BUNDLE) was completed and will support future MSR programs. The BUNDLE hardware was used to help develop SACAs, which can be used by different PIs.

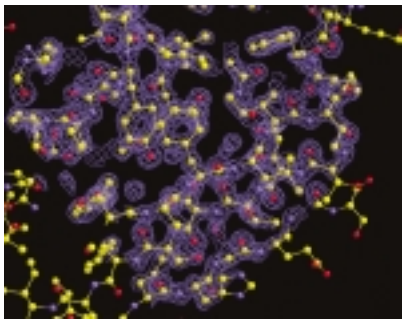
Samples for two materials science investigations, 1) Solidification Using a Baffle in Sealed Ampoules, and 2) Toward Understanding Pore Formation And Mobility During Controlled Directional Solidification In A Microgravity Environment Investigation, were delivered to the Kennedy Space Center (KSC) and will soon be flown to the *ISS*.

Noteworthy progress was also made in the radiation initiative, which aims to develop new radiation shielding materials for future spacecraft. The initiative uses an inexpensive, recoverable test-bed for materials testing. Two hundred sixteen peer-reviewed journal articles and numerous presentations were generated by researchers in the MSFC Materials Sciences Program.

Biotechnology

In accordance with National Research Council guidelines, the Biotechnology Discipline moved forward with implementation of the Structural Biology Initiative. The goals of this initiative are to demonstrate the value of and offer low gravity research capability to the structural biology community and improve the pace of space research to match that of the ground research. Structural Biology Initiative goals that were accomplished in FY 2001 include:

- Creation of an NRA
- Advancements in the creation of Iterative Biological Crystallization (IBC) capability
- Creation of an Associate Investigator program to provide *ISS* laboratory access to any investigator in the structural biology community



Model of pea lectin at a resolution of 1.2 Angstrom grown using EGN on *ISS* Mission 2A.2b.

- Formulation of plans to establish the NASA Institute for Structural Biology (NISB) at the Hauptmann-Woodward Medical Research Institute.

In June 2001, OBPR selected 43 researchers to receive grants totaling approximately $27 million over 4 years to conduct biotechnology research on Earth and in space.

NASA's IBC Program began producing cutting-edge equipment designed to miniaturize and automate the process of macromolecular crystallization. This technology reduces the area needed by laboratories full of equipment to an area the size of a thumbnail. This capability is a cornerstone for accelerating the time between idea formation and data recovery for scientists desiring to perform structural biology experiments in low gravity.

The Associate Investigator Program was set up to provide a means for the external scientific community to obtain rapid access to microgravity for structural biology investigations. This system allows the program to efficiently fly the highest-quality science and track the results. These actions optimize the service provided to the structural biology community.

An important part of the Structural Biology Initiative was to establish an external panel to assist the MSFC biotechnology program. Plans for the formation of the NISB—to be located at the Hauptman-Woodward Medical Research Institute in Buffalo, NY—began in FY 2001. The NISB was designed to conduct external, independent peer review of all structural biology and crystal growth samples that fly in NASA's Physical Sciences Division within the OBPR and to offer preflight and postflight characterization of flight samples including detailed double-blind comparison of crystal quality between space-grown and Earth-grown crystals.

After 2 years of very limited access to space, FY 2001 turned out to be a year of firsts for the program. Not only were the first structural biology experiments conducted aboard *ISS*, but the preliminary results of those experiments were very encouraging to the science community.

Basic fibroblast growth fact (bFGF) crystals like the ones shown here were grown aboard *ISS* on *ISS* mission 2A.2b from April 2001 to June 2001. Inhibition of bFGF activity is one anti-cancer therapeutic strategy.

The first biological crystal growth experiments conducted aboard the *ISS* produced higher quality thaumatin crystals than ever reported for those grown on Earth. The crystal produced 50 percent more data than the best ground-grown crystal (1.47 Å) and 200 percent more data than earlier reports of thaumatin crystals in scientific literature (1.65 Å).

The Enhanced Gaseous Nitrogen (EGN) Dewar was flown on three missions during the year. The three missions allowed experiments on a total of 881 samples aboard *ISS* with mission durations of approximately 40 days each.

The Student Access to Space Program continued with biochemistry workshops and classroom activities that engage students in experiments in the environment of microgravity. Approximately 231 students, 191 teachers, and over 178 schools in six states participated. Over 395 samples and 7 types of biological macromolecules were flown to *ISS* as part of this program.

ISS Assembly Flight 6A included the first series of exploratory experiments for longer duration missions aboard *ISS*. Equilibration studies produced data that will help future investigators optimize conditions for macromolecules for a particular mission. The analysis of these samples is still underway.

The Dynamically Controlled Protein Crystal Growth experiment was flown successfully to the *ISS*. For the first time, dynamic control of crystallization experiments was conducted from the ground. This was the first microgravity payload that allowed automated imaging of the experiments in progress. The analysis of the results is underway.

A Universities Space Research Association/NASA research team in collaboration with scientists at Argonne National Laboratory, for the first time, mapped internal defect structures in the bulk of protein crystals using phase sensitive x-ray diffraction imaging. This new method renders a helping hand in efforts to understand crystal quality.

Over 85 peer-reviewed journal articles and numerous presentations were generated from researchers in the MSFC Biotechnology Program.

Glovebox

The Microgravity Science Glovebox (MSG) flight unit was formally delivered to KSC in October 2001. The MSG is a joint NASA/European Space Agency (ESA) development under the management of MSFC. Acceptance and verification testing of the flight unit were conducted with coordination from the ESA and NASA Centers KSC, MSFC, and JSC. The MSG is among the first major research facilities to be activated on the *ISS*. MSFC is responsible for the operations and experiment integration for the research community.

The MSG is currently integrated for flight to the *ISS*. Due to *ISS* manifest changes, the original flight opportunity on UF–1 was changed to UF–2. MSG will be installed into the *ISS* upon its delivery. Once the installation and checkout of MSG is completed it will be ready for operation.

Materials scientist Dr. Aleksandar Ostrogorsky examines a sample container in the glovebox; his research will advance understanding of materials used to make semiconductors.

Two materials science experiments and one fluids experiment will be the first research performed in the new facility. Flight hardware and associated samples will also be flown to *ISS* with the MSG on the UF–2 mission. These flight experiments will be carried out during *ISS* increment five and increment six. The Glovebox Integrated Microgravity Isolation Technology (g-LIMIT) system, originally scheduled to fly with the first complement of payloads, is now scheduled to launch on a later mission.

Materials Science

Deliver four Science Concept Reviews.

Materials Science discipline successfully completed four SCRs. The SCRs were conducted for the following: Dr. Michael R. Banish/ University of Alabama in Huntsville —Thermophysical Property measurements of Te-based II-VI Semiconductor Compounds; Dr. John Pojman/University of Southern Mississippi—Frontal Polymerization in Microgravity; Dr. Martin Glicksman/Rensselaer Polytechnic Institute—Evolution of Local Microstructures: Spatial Instabilities of Coarsening Clusters; and Dr. Frank R. Szofran/ MSFC—Reduction of Defects in Germanium-Silicon.

Deliver six Requirements Definition Reviews.

Headquarters-directed budget cuts to the program deferred or deleted the projects scheduled for these reviews. Hence none of the planned RDRs were conducted.

Release Materials Science 2000 NASA Research Announcement.

The year 2001 NRA, NRA–01–OBPR–05, Materials Science: Ground-Based Research opportunities in Biomaterials and Radiation Shielding, was released.

Molecular Biotechnology

Fully implement the recommendations of the National Research Council.

In accordance with National Research Council guidelines, the Biotechnology Discipline moved forward with implementation of the Structural Biology Initiative. The goals of this initiative are to demonstrate the value of and offer low gravity research capability to the structural biology community, and to improve the pace of space research to match that of the ground research. Structural Biology Initiative goals that were accomplished in FY 2001 included: creation of a NASA research announcement; advances in the creation of IBC capability; creation of an Associate Investigator program to provide access to *ISS* laboratories to any investigator in the structural biology community; and formulation of plans to establish the NISB at the Hauptmann-Woodward Medical Research Institute.

Develop and implement a method to radically accelerate the time between idea and data recovery for scientists desiring to perform Structural Biology experiments in low gravity.

The Associate Investigator program was set up to provide a means for the external scientific community to obtain rapid access to microgravity for structural biology investigations. This system allows the program to efficiently fly the highest-quality science and to track the results. These actions optimize the service provided to the structural biology community. In addition, a technology development was begun to allow rapid adjustment of experimental conditions.

Identify, form partnership, and perform exploratory experimentation in biomaterials and nanotechnology to support NASA goals in Bioastronautics and Astrobiology.

NASA's IBC Program began producing cutting-edge equipment designed to miniaturize and automate the process of macromolecular crystallization. IBC teamed with a leader in lab-on-a-chip technology, Caliper Technologies Corp., to begin developing custom chips using LabChip® technology to enable researchers to set up experimental conditions in space, to monitor biological molecular crystals as they grow, and to change experiment conditions remotely as needed. This micro- and nanofluidic technology reduces the functions performed by laboratories full of equipment to an area the size of a thumbnail.

Glovebox

Deliver the Microgravity Science Glovebox Facility to ISS for the UF–1 flight.

MSG flight unit was formally delivered to KSC in October 2001. Because of adjustment of the *ISS* schedule, the MSG flight was delayed until the UF–2 launch.

Deliver the vibration isolation system Glovebox Integrated Microgravity Isolation Technology to ISS for UF–1 flight.

The g-LIMIT system, originally scheduled to fly with the first complement of payloads, is now scheduled to launch on a later mission.

Integrate three experiments into Microgravity Science Glovebox for UF–1 flight.

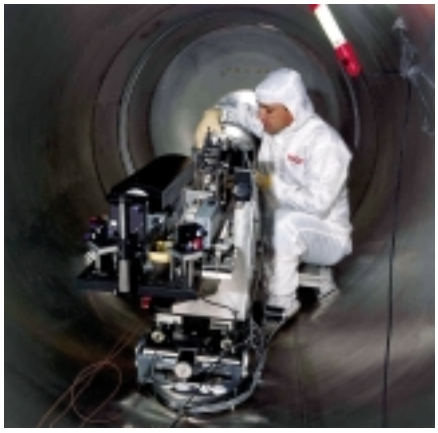
Two materials science experiments and one fluids experiment will be the first research performed in the new facility. Flight hardware and associated samples will also be flown to *ISS* with the MSG on the UF–2 mission. These flight experiments will be carried out during *ISS* increment 5 and increment 6.

Space Optics Manufacturing Technology

The Space Optics Manufacturing Technology Center (SOMTC) was created in the 1999 Marshall Space Flight Center (MSFC) reorganization as an integral part of the Science Directorate. SOMTC's purpose is to serve as the national focal point for developing advanced technologies supportive of large, lightweight, and low-cost optics for space use. This requires breaking old paradigms and finding innovative applications for promising technologies.

Next Generation Space Telescope

The history of astronomical optical systems has shown a continuous drive towards lighter optical elements. The primary mirror in the ground-based Hale telescope at Mt. Palomar (using 1947 technology) weighs roughly 550 kg/m^2. The Hubble Space Telescope primary (using 1980s technology) weighs about 150 kg/m^2. MSFC is supporting Goddard Space Flight Center (GSFC) by leading the development of ultralight optics for the Next Generation Space Telescope (NGST). The design goal for the NGST mirror, scheduled to fly around 2009, is 15 kg/m^2. MSFC is participating in the management of two major mirror development programs: The New Mirror System Demonstrator (NMSD) and the Advanced Mirror System Demonstrator (AMSD). Four different mirror technologies ranging from 1.6 m to 2.0 m in diameter are being developed that meet the NGST weight goal. The AMSD program is unique in that funding is being provided by multiple agencies, including NASA and the United States Air Force.



Measurements in the X-ray Calibration Facility chamber on developmental mirrors.

Constellation X

SOMTC is a key resource in mirror technology support to GSFC on the next generation x-ray mission called Constellation X. This mission will be a follow-on to the recently launched Chandra X-Ray Observatory. Constellation X is planned for new mission start around 2005 and will require lighter-weight x-ray optics than previously developed.

During 1999, SOMTC fabricated the pathfinder shell for this mission with a thickness of 0.25 mm. In 2000, SOMTC fabricated a pathfinder x-ray mirror shell with a wall thickness of only 0.15 mm. This shell satisfies the weight requirement for the Constellation X mission. This pathfinder x-ray shell was six times lighter than previous shells at 0.5 m diameter. SOMTC and its partners are on track to generate further improvements in increased angular resolution to meet the mission requirements.

Research

Areas of research expertise at SOMTC include: Optical physics, photonics, electro-optics, laser systems, diamond turning and precision engineering of optical surfaces, test and analysis of optical system stray light performance, test and analysis of x-ray optical systems, and development of unique and innovative methods for optical fabrication, testing, and coating.

Research efforts in the area of laser physics led to the development of a solid-state Rodamine-impregnated polymer used as a lasing gain medium. A master oscillator and light amplifier were demonstrated using this new material. Applications for use range from power beaming and energy transfer to new methods for in-space propulsion.

SOMTC conducts research efforts in large-area fresnel lens development. Fresnel lenses consist of concentric annular rings with a specific prescribed shape that allows all rings to act as a single lens with a common focus. The rings all lie in a common plane, making a fresnel lens extremely flat as compared to a common refractive lens. Fresnel lens research efforts contribute to three different concepts currently being studied for use in detecting high-energy gamma rays and their interaction with the upper atmosphere.

Metrology

SOMTC is developing a center for calibration and metrology of large optical components and systems. The facilities and expertise of SOMTC include optical fabrication, optical metrology, stray light scattering, and surface morphology. These are being applied to a number of NASA, Department of Defense, Department of Energy, National Oceanographic and Atmospheric Administration, industry, and academic needs.

FY 2001 Space Optics Manufacturing Technology Metrics and Performance

Produce a solar-collector-quality mirror with an areal density <0.1 kg/m^2.

A membrane mirror is currently at the SOMTC. The mirror appears to be better than solar-collector quality and is awaiting optical testing.

Complete the installation of the inductive edge sensors on a segmented ground-based telescope.

Installation of the inductive edge sensors on the Hobby-Eberly Telescope has been completed. This system is being used in daily operations. The second part of the process, maintaining the global radius of curvature, is underway and will be completed in FY 2002.

Produce 0.5-m diameter replicated optic of optical quality and <1.0 kg/m^2.

MSFC has teamed with Alabama A&M University for the production of replicated electroformed optics. Due to initial funding delays, startup was delayed. The first replicas have been produced and await metrology.

For Next Generation Space Telescope—test two additional mirror technologies as the suppliers deliver them.

The expected testing of the final mirror for the NMSD has again been delayed. It is not meeting specifications at the contractor. Two additional mirrors were tested; a third test was performed on the cryo-figured Small Beryllium Mirror and a mirror produced under a corporate Independent Research and Development program at Goodrich during the plan year.

For Constellation X-ray, continue improvement of the resolution by a factor of two.

The Constellation X-ray Program has made a decision on the technology to be used on their program and no longer require the full shell replication technology being developed at SOMTC. SOMTC continues to support the Constellation X-ray Program with mandrel procurement, vacuum coating, and assistance with alternative replication processes.

Implement continued process improvements in the X-ray Calibration Facility to reduce the cost of testing by an additional five percent.

The X-ray Calibration Facility staff continued to improve processes that allow 24-hour-a-day, 7-days-a-week operation of the facility with single shift staffing. Multiple-shift staffing is only required during data-taking periods. This improves the throughput and increases the efficiency of the operation by more than five percent. An additional small cryo chamber has been placed in service that allows testing of smaller systems at a greatly reduced cost in consumables.

Install the additional single point diamond turning machine and establish it as a financially self-sufficient group within two years.

Due to changes in the Constellation X-ray Program during the plan year, plans for installing an additional Single Point Diamond Turning machine were shelved in favor of setting up the Precision Optical Generator (POG). Mechanical installation of the POG is near completion and upgrade of the controllers is underway.

Demonstrate a four-fold efficiency increase for the solar pumped laser.

The Solar Pumped Laser work has come up with a negative result. The expected efficiency increase using direct optical coupling to a selective emitter for the pump source was not realized. This work did result in a Master of Science thesis topic of the researcher involved.

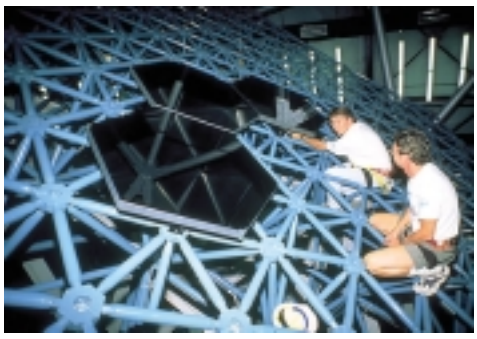
Define a 2–10 megawatt Solar Electric Propulsion System for outer planet exploration using derived Space Solar Power Program technology.

This task was completed for the Space Solar Power Program.

Develop and demonstrate a neuro-fuzzy logic controller for active segmented optics.

The neuro-fuzzy logic controller work was completed by a researcher hired under the summer faculty program and was implemented on one of the segmented mirror testbeds, Systematic Image-Based Optical Alignment.

Large copper Fresnel Mandrel on SOMTC diamond turning machine.



Mirror installation on truss of Hobby-Eberly Telescope with Segment Alignment Maintenance.

Other Programmatic Assignments

The *International Space Station*

The *International Space Station* (*ISS*) is a U.S.-led, international partnership program to build and operate a unique, world-class orbiting laboratory, free from the effects of gravity. Long-term scientific and technology development is being conducted for the benefit of life on Earth and the continued exploration and development of space.

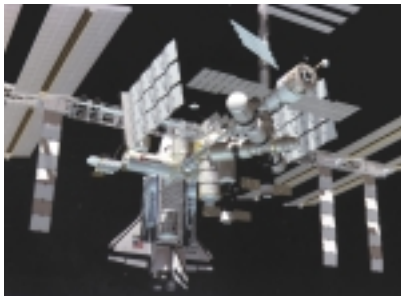
Marshall Space Flight Center (MSFC) supports the *ISS* program through task agreements with the *ISS* Program Office at the Johnson Space Center (JSC). MSFC plays a vital role in building, operating, and utilizing the *ISS* for NASA through the performance of these tasks.

Specifically, MSFC is providing management oversight of Nodes 2 and 3, which will be provided by the Italian Space Agency (ASI) and their contractor, Alenia. The purpose of these sections of the U.S. On-Orbit Segment is to act as building blocks to connect utilities and provide a pressurized passageway between berthed elements. Commands and data will be distributed/transferred, as well as audio, video, electrical power, thermal energy, atmosphere, and water.

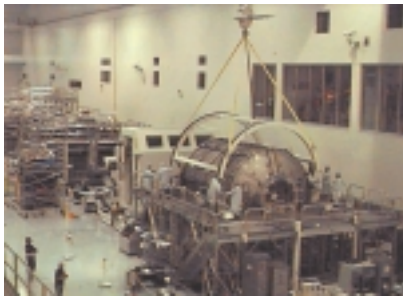
MSFC is responsible for the development of the regenerative life support systems for the *ISS* crew and the research animals. The *ISS* crew will be provided a comfortable environment in which to live and work. Collectively, this is called the Environmental Control and Life Support System (ECLSS). The MSFC-managed portions of the ECLSS will include the development of the Water Recovery System (WRS) to recycle wastewater (including urine) to produce drinking (potable) water, store and distribute potable water, and use the WRS recycled water to produce oxygen for the crew via the Oxygen Generation System.

MSFC is a leader in the development of payload facilities for the *ISS*. Our innovative Expedite the Processing of Experiments to Space Station (EXPRESS) rack provides simple, standard interfaces to accommodate drawer-level, locker, and modular-type payloads from all science disciplines. The EXPRESS rack concept provides for a simple and shortened integration cycle. By leveraging off of a common avionics design, MSFC has been able to develop derivative payload facilities for other NASA customers at a reduced cost for the *ISS*. Future *ISS* maintenance costs will be reduced through the ability to share spare replacement units and repair depots on the common avionics.

Four EXPRESS racks, four EXPRESS transportation racks and one functional checkout unit were planned for development in FY 2001. Engineering Integration of payloads for the stages 6A and



International Space Station.



MPLM Flight Module 2 in the Element Rotation Stand at Kennedy Space Center.

Payload Operations Integration Center.

7A.1 were planned for this period. Four EXPRESS racks were flown to the *ISS* in FY 2001. EXPRESS rack 1 and EXPRESS rack 2 were launched on STS–105. EXPRESS rack 4 and EXPRESS rack 5 were launched on STS–103. EXPRESS rack 1 and EXPRESS rack 2 were used to support checkout of the U.S. Laboratory Module Destiny. Development and delivery of the racks met schedules for integration at Kennedy Space Center (KSC). Four EXPRESS transportation racks were delivered to KSC. The transportation racks will be used on future flights to transport payloads to the *ISS*. In addition, an EXPRESS functional control unit was delivered to KSC to test payloads when an EXPRESS rack is not available. Engineering integration for the EXPRESS racks was performed for stage 6A and stage 7A.1. FY 2001 was the first time EXPRESS racks were sent to the *ISS*. Issues that were worked during integration have been evaluated for process improvement and implemented as appropriate for future development and integration activities. The racks have safely operated on the *ISS* and have successfully supported payload operations.

In addition, MSFC provides various types of hardware to carry essential equipment into space. Among these is the Multipurpose Logistics Module (MPLM), which serves as the *ISS* "moving van." The MPLM, loaded with laboratory racks filled with experiments, as well as supplies and equipment, travels in a space shuttle payload bay to dock via the robotic arm to the *ISS*. There, the crew unloads and reloads the MPLM to start the process all over again, giving a quick turnaround to support the *ISS* mission schedule. ASI/Alenia has provided three MPLMs (the third module was delivered to KSC in January 2001). MSFC is responsible for engineering oversight and sustaining engineering of the MPLM modules.

MSFC's Testing, Manufacturing, and Support Team provides technical expertise to *ISS* design and development teams. The team supports the areas of hardware design, fabrication, manufacturing, and testing—including structural, dynamic, environmental, electromagnetic, and acoustic.

MSFC is also responsible for the management, integration, and execution of payload operations and utilization activities on board the *ISS*. The Payload Operations Integration Function is responsible for various aspects of payload operations integration including mission planning, crew displays and procedures, and crew and ground support personnel training. The Payload Operations Integration Center, located at MSFC, is the *ISS* Program focal point for payload operations. MSFC controllers staff the facility and interact with the worldwide scientific research community to plan and conduct payload operations on board the *ISS*.

EXPRESS Rack #1 in processing at KSC for *ISS* Flight 6A.

Mock-ups of the two Water Recovery System racks are shown on the left, the Oxygen Generation System rack is on the right.

Flight 3A Spacelab Pallet/Pressurized Mating Adapter-3.

FY 2001 *International Space Station* Metrics and Performance

Complete Spacelab Pallet/Pressurized Mating Adapter–3 Mission for ISS *Flight 3A, STS–92.*

Carrier integration was completed on schedule to meet the *ISS* program schedule for flight 3A in October 2000.

Complete Spacelab Pallet/Space Station Remote Manipulator System Mission for International Space Station *Flight 6A, STS–100.*

Carrier integration was completed on schedule to meet the *ISS* program schedule for flight 6A in April 2001.

Complete Spacelab/Oxygen/Nitrogen Tank Orbital Replacement Units Mission for International Space Station *Flight 7A, STS–104.*

Carrier integration was completed on schedule to meet the *ISS* program schedule for flight 7A in July 2001.

Define and negotiate the contract for the U.S. Propulsion System development effort.

The *ISS* Program Office cancelled this effort in FY 2001.

Deliver the Vapor Compression Distillation flight experiment to the launch site.

Hardware was delivered to KSC as scheduled to meet the *ISS* program schedule for the upcoming STS–107 mission (currently planned for January 2003).

Complete the Critical Design Review for the Water Recovery and Oxygen Regeneration Systems.

Due to changes in *ISS* program office schedules, this review will be completed in FY 2002.

Deliver the Lightweight Multipurpose Experiment Support Structure Carrier and associated Flight Support Equipment to the launch site.

This hardware was delivered on schedule to KSC and was flown aboard *ISS* Flight UF–1, STS–108.

Deliver Multi-Purpose Logistics Module Flight Module 3 to the launch site.

This hardware was delivered to KSC in January 2001, as scheduled.

Provide Marshall Space Flight Center Certification of Flight Readiness Statements for Multi-Purpose Logistics Module Flight Module 1 and Flight Module 2.

This effort was completed on schedule to support the Stage Operation Readiness Review for Flight 5A.1 (Flight Module 1) and Flight 6A (Flight Module 2).

Complete Node 2 primary structure acceptance tests and begin flight unit integration.

Primary structure acceptance tests were completed in June 2001. Flight unit integration underway.

Conduct Design Review 2 for Node 2.

Design Review 2 was completed as scheduled.

Complete development and integration of Expedite the Processing of Experiments to the Space Station Racks in accordance with flight schedules.

Development and delivery of the racks met schedules for integration at KSC.

Implement remote payload command and control capabilities for Flight 5A.1.

This was implemented successfully with the release of Build 4.2–7.3.1 in February 2001.

Conduct Integrated Payload Operations on International Space Station.

Integrated Payload Operations on *ISS* began March 2001 and continue to be executed round the clock in the Payload Operations Center at MSFC.

Conduct operational readiness reviews to support International Space Station *flight schedules.*

Operational readiness reviews were conducted jointly with the Mission Operations Directorate at JSC for *ISS* flights in FY 2002.

Certify readiness for payload operations in accordance with International Space Station *program schedules in FY 2001.*

Payload operations readiness certification was provided to the *ISS* Program for all *ISS* flights in FY 2001.

Initiate the conduct of International Space Station *remote science operation, supporting the schedule requirements of international partners and U.S. users.*

Remote science operation was implemented successfully, with over 15 remote sites around the United States, Canada, and Italy. The conduct of *ISS* remote science operations started with Flight 5A.1 in February 2001 and is still ongoing as required to support the schedule of International Partners and U.S. users.

Advanced Projects

The Advanced Projects Office managed the Space Solar Power (SSP) Exploratory Research and Technology (SERT) activity, which included analysis of systems concepts, technology development, and demonstrations, to identify viable approaches to SSP for Earth, planetary surface, and space applications. Additional responsibilities included technical support to the NASA next-decade planning mission architecture studies for fuel aggregation, and participation and assistance in the management of the Human Exploration and Development of Space (HEDS) Technology Commercialization Initiative (HTCI).

New Space Industries could result from HTCI activity.

FY 2001 Advanced Projects Metrics and Performance

Provide updates on the Space Solar Power Exploratory Research and Technology activity, including concept analysis, technology roadmaps, and recommendations on near-term technology, research, development, and demonstrations.

Updates have been provided to Code M as requested, including recommendations on demonstrations.

Demonstrate Space Solar Power technologies in solar power generation, power management and distribution, and wireless power transmission.

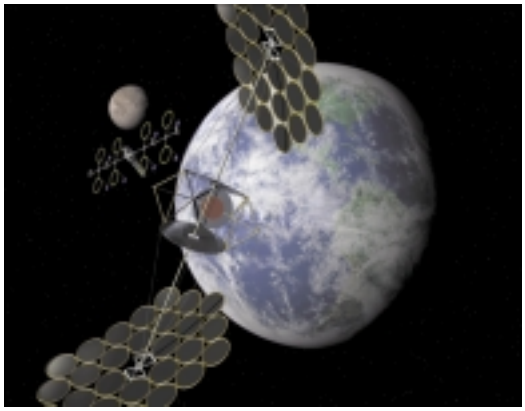
Ground demonstrations of SSP technologies have been initiated in each of these areas.

Provide updates on fuel aggregation studies in support of next-decade planning studies.

Next-decade planning activities have evolved to include more topics. Updates have been provided to Code M as requested.

Provide management support and concept definition of applications for space utilities and power in the Human Exploration and Development of Space Technology Commercialization Initiative, including solar power systems and fuel depots in space.

Support was provided to the HTCI activity as requested in FY 2001 for both SSP and fuel depots in space.



Space Solar Power concept from the SERT activity.

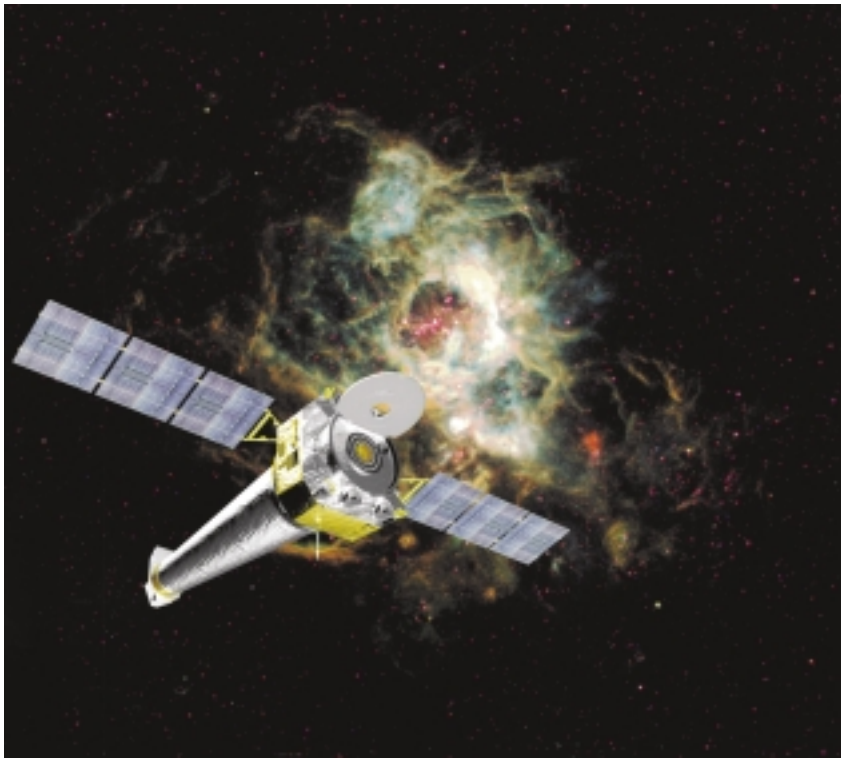
Chandra

MSFC manages the operation of the MSFC-developed Chandra X-ray Observatory through the Operations Control Center and the Chandra X-ray Center at the Smithsonian Astrophysical Observatory in Cambridge, MA. Program goals are to determine the nature of celestial objects from normal stars to quasars, understand the nature of physical processes that take place in and between astronomical objects, and understand the history and evolution of the universe. These goals are being accomplished by extending the range of astrophysical observations significantly beyond that of previous x-ray observatories through increases in sensitivity and resolution.

FY 2001 Chandra Metrics and Performance

Fully acceptable performance is defined as instruments meeting nominal performance expectations, completing 80 percent of preplanned and commanded observations, with 95 percent of science data recovered on the ground and provided to the observer. Viewing efficiency (time in observing state versus total time) will be greater than 50 percent. Operational lifetime will exceed 5 years with a goal of 10 years.

Chandra has exceeded all FY 2001 performance metrics.



Chandra X-ray Observatory.

National Space Science and Technology Center

The National Space Science and Technology Center (NSSTC), headquartered in Huntsville, AL, is a collaborative research and education institution that provides an environment for selected key scientific disciplines. It consists of researchers and resources from government, academia, and industry collaborating in an environment that enables cutting-edge basic and applied research and fosters education of the next generation of scientists and engineers. It is a unique blending of people, facilities, and tools to encourage advances in earth science, space science, materials science, biotechnology, optics, energy technology, space propulsion, and information technology.

The research performed by the NSSTC covers the range of maturity from pure science to technology development to mission operations and data analysis. In appropriate disciplines, laboratory experiments, sounding rockets, balloons, and aircraft are used as platforms for the investigations being pursued. Where appropriate, experiments are flown on manned and unmanned spacecraft. Educational activities include both graduate level and undergraduate level for students at the partnering educational institutions, as well as outreach and teacher training for K-12 education. Partnering educational institutions currently include the University of Alabama, University of Alabama Huntsville, University of Alabama Birmingham, Auburn University, Alabama A&M University, the University of South Alabama, and Tuskegee University.

The National Space Science and Technology Center.

The NSSTC is a partnership between NASA and the State of Alabama, through the Alabama Space Science & Technology Alliance, to perform research meeting the nation's needs. The NSSTC is the culmination of the efforts of NASA and the State of Alabama over a two-year period in which NASA invested $9 million and Alabama invested $6.9 million to acquire the core facility for the NSSTC. The University of Alabama in Huntsville, acting as the fiscal agent for the state, procured a facility and executed the renovations.

During FY 2001, the following key accomplishments occurred:

- Occupancy of the core facility was completed.
- NASA provided funds to initiate the construction of an 80,000 ft^2 annex. The annex houses the much-needed laboratory space required by the NSSTC scientists.
- A streamlined process was developed that expedited formal arrangements with industry partners.
- An industry request was received to establish a formal alliance.
- Ongoing discussions have been held with the U.S. Army Redstone Arsenal regarding partnership at the NSSTC.

Global Hydrology and Climate Center

Through the Global Hydrology and Climate Center (GHCC), a joint venture with academia, MSFC engages in research, education, and the development of Earth science applications. The GHCC focuses on using advanced technology to observe and understand the global climate system and applies this knowledge to agriculture, urban planning, water resource management, and operational meteorology. Areas of emphasis include observations of lightning, wind, and the use of other measurements for the study of the Earth's global hydrologic and energy cycles.

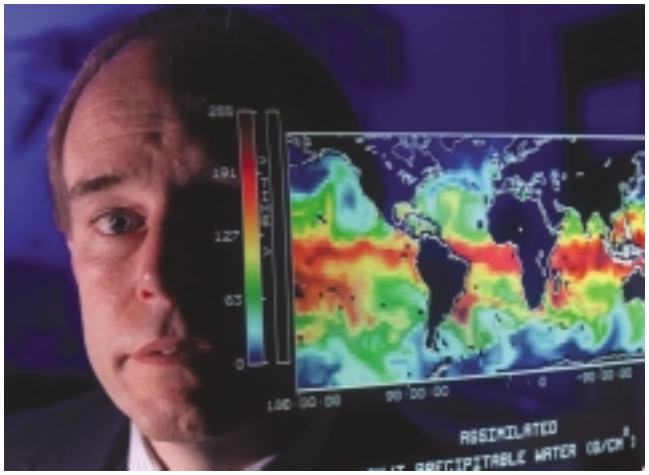
The GHCC accomplished global water cycle research emphasizing the use of advanced satellite measurements for determining fundamental atmospheric water variables, their phase, and three-dimensional transports, and then translating the findings into improved climate prediction models. To emphasize increased accuracy in surface hydrology and dispersion of chemical pollutants, GHCC uses advanced satellite data assimilation techniques in regional weather prediction models.

A major focus in FY 2001 is strengthening the atmospheric lightning program through continuing research and acquisition of global lightning data from the Lightning Imaging Sensor (LIS) onboard the Tropical Rainfall Measurement Mission (TRMM), understanding the relationship between lightning flash rate and severe storm onset, and establishing a collaborative program with the National Oceanic and Atmospheric Administration (NOAA) or a commercial entity for acquisition of lightning data from geosynchronous orbit to improve severe storm prediction.

To support archaeological studies and contribute to Earth Science Enterprise global land use classification, land use change research in Central America is being performed. In addition, GHCC is evaluating the interannual climate variability of the southeastern U.S. and determining implications on key economic sectors and increasing the understanding of sources and sinks for tropospheric ozone and its transport.

Restructure of the coherent wind lidar technology program includes ground-based technology development and data validation, and participation with other Centers in planning for future flight opportunities or data purchases. Other activities include developing improved satellite retrieval techniques to measure and monitor atmospheric aerosol concentration, its transport, and its influence on radiative properties of clouds.

Research results from urban heat island studies were provided to state and local governments for utilization, and the Global Hydrology Resource Center will continue developing its capabilities through component data information systems for LIS, Microwave Sounding Units (MSUs), Advanced Microwave Sounding Units (AMSUs), and Special Sensor Microwave Imager measurements; Earth Science Information Partners for Advanced Microwave Scanning Radiometer data processing; and efficient accessibility by the science community.



Map of moisture over global oceans.

FY 2001 Global Hydrology and Climate Center Metrics and Performance

Provide demonstration of an improvement to climate modeling or understanding of variability, based upon utilization of satellite data.

A study was completed that quantified interannual variability of precipitating ice particles in deep convection over the tropical oceans and showed how it is strongly related to sea-surface temperature. This finding has resolved certain discrepancies in precipitation estimates from the TRMM satellite.

Demonstrate significant improvement in a regional forecast model through the use of geostationary and other satellite data assimilation.

Additional cases of improved short-term forecasts of precipitation were demonstrated; interest in this work by the National Weather Service grew beyond the Northern Alabama region.

Continue successful operation of the Lightning Imaging Sensor onboard the Tropical Rainfall Measurement Mission.

LIS continued highly successful operations, building the tropical/subtropical lightning database the fourth consecutive year.

Publish three scientific papers on the importance of lightning observations in severe storm and/or climate dynamics understanding.

At least five journal articles were produced by the MSFC atmospheric electricity team, covering various subjects including the importance of in-cloud versus cloud-to-ground lightning for storm diagnostics and prediction and the effects of El Niño on thunderstorms in the southeastern U.S., as evidenced in space-based and other lightning data.

Assist the University of Alabama in Huntsville in developing a plan for a lightning sensor on a geosynchronous satellite for the University Earth System Science Program.

Proposal completed and was selected for final competition, but the University Earth System Science program was cancelled by NASA HQ.

Support development of the Mesoamerican Biological Corridor per NASA/ Central American Commission on Environment and Development Memorandum of Understanding, including development of a Japanese Earth Resource Satellite–1 Synthetic Aperture Radar mosaic over Central America.

A Japanese Earth Resource Satellite radar mosaic was completed and distributed on CDs by NASA to the presidents, ministers, scientists, and managers of Central America. The radar mosaic was also incorporated as the base map into the Central American geographic information system and will be used for interdisciplinary research and for the selection of corridor routes for protected areas.

Foster the application of remote sensing data for analysis of urban landscape change and urban heat island characterization in one to two cities.

Application of remote sensing data for analysis of urban landscape change and urban heat island has been completed for the initial target cities and work is continuing.

Obtain funding and begin development of a coherent wind lidar ground-based technology test-bed and wind validation facility.

This work has been transitioned to Langley Research Center.

Fully transition the Microwave Sounding Unit global temperature monitoring effort to include new Advanced Microwave Sounding Unit data.

The global temperature monitoring effort has now successfully included data from the new AMSUs flying on the NOAA–15 and NOAA–16 satellites. The AMSUs have been found to provide more robust global temperature measurements, with a higher level of agreement between the two AMSU copies than was seen in the 22+ years of measurements from the older MSUs.

Successfully implement the Advanced Microwave Scanning Radiometer– Earth Observing System Science Investigator-led Processing System upon launch of the Aqua satellite.

Milestones were successfully met for Mission Operations Science Systems tests. Awaiting Aqua launch later in FY 2002.

Continue successful operation of the Global Hydrology Resource Center—with growth as indicated in the Earth Science Enterprise target goals—and continue in the role as a major contributor to the running and organization of the Federation of Earth Science Information Partners.

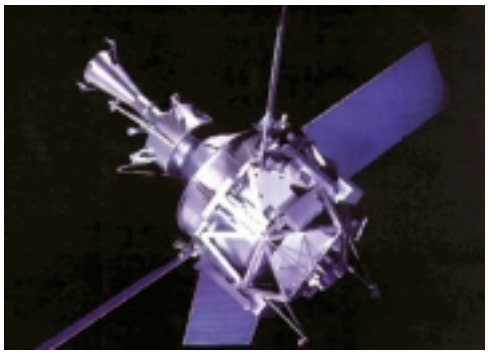
The CAMEX–4 mission was successfully supported. Continued support was provided to data processing and the distribution of science products for LIS. A continued leadership role was maintained in the Federation of Earth Science Information Partners.

Space Science Research

MSFC is designated as a Supporting Center to Goddard Space Flight Center for the Space Science Enterprise. MSFC manages the Chandra X-Ray Observatory, Gravity Probe–B (GP–B), Solar–B, Solar X-Ray Imager (SXI), and the Gamma Ray Large Area Space Telescope (GLAST) Burst Monitor (GBM) for Code S.

MSFC is responsible for managing the overall design, development, integration, testing, and flight operations of the GP–B flight experiment. The GP–B objective is to test two extraordinary predictions of Einstein's Theory of General Relativity, namely "geodetic precession" and "frame dragging," both of which describe distortions in the space-time con-tinuum. In order to test these subtle effects, GP–B will fly ultra-precise gyroscopes aboard a drag-free spacecraft containing the world's largest space-qualified dewar.

MSFC also manages the SXI, Solar–B, and the GBM, and conducts fundamental research in six disciplines—cosmic-ray physics, gamma-ray astronomy, x-ray astronomy, solar physics, space plasma physics, and astrobiology.



Gravity Probe–B.

Gravity Probe–B

MSFC manages the GP–B science payload and will manage the upcoming science mission. This mission will measure key features of Einstein's General Theory of Relativity by making precise measurements of the space-time continuum in near-Earth orbit. The significant highlights for the program in FY 2001 included successful completion of payload acoustic testing, integrated payload testing, and shipment of the payload to the spacecraft contractor for integration.

FY 2001 Gravity Probe—B Metrics and Performance

Complete final integration/test of Gravity Probe–B science payload in FY 2001.

Integration and testing of the GP–B science payload was completed as planned.

Confirm a mission lifetime of 16 months.

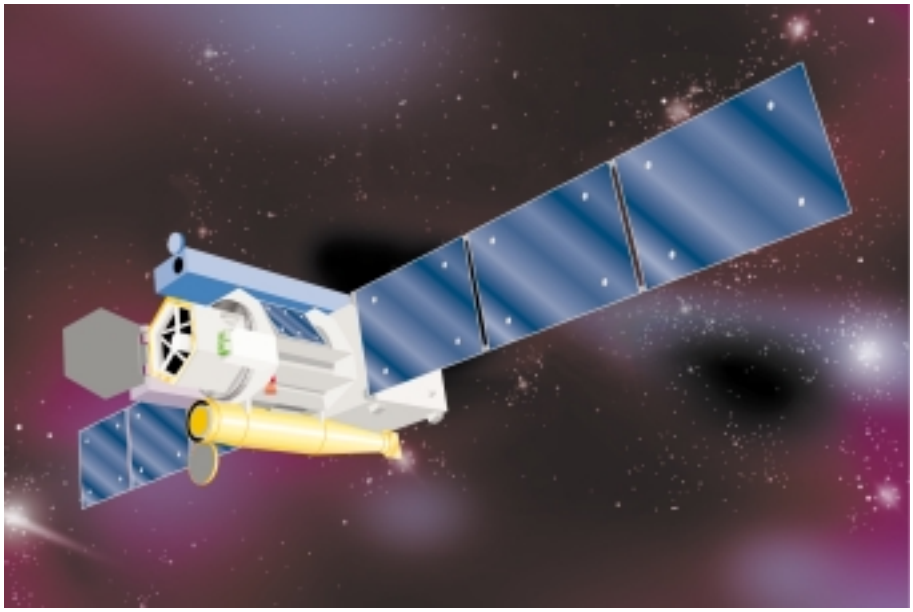
All testing to date confirms this expectation.

Confirm a measurement accuracy of 0.5 milliarcseconds per year.

All testing to date confirms this expectation.

Solar–B

MSFC also manages the U.S. contribution to the Japanese Solar–B mission. The goal of this international mission is to increase our understanding of the Sun and its impact on Earth. Scheduled for launch in 2005, this mission includes a significant contribution from the U.S. investigators and industry. In 2001, the Critical Design Reviews were completed for each of the U.S. instrument elements. The U.S. electrical engineering models were delivered to the Japanese Institute of Space and Astronautical Sciences (ISAS) in July 2001 as planned.



Solar–B.

FY 2001 Solar–B Metrics and Performance

Achieve launch readiness by August 2004.

Launch was moved to September 2005 per the request of the ISAS/Japan. Requirements review was completed in September 1999. Concepts studies were completed in October 1999. Preliminary Design Reviews were completed in May 2000.

Critical Design Reviews were conducted in July, October, and December 2001.

Mission lifetime of three years.

This metric is on track.

Deliver engineering models by February 2001.

Delivery of the engineering models was moved to July 2001 to reflect new launch date and to accommodate Japanese schedule. The required U.S. electrical protomodels were delivered to ISAS in July 2001. Mechanical test models are on track for March 2002 delivery.

Deliver of focal plane instrument to ISAS by October 2002.

Delivery of the focal plane instrument to ISAS was moved to October 2003 to reflect new launch date.

This metric is on track.

0.5-m optical telescope resolution of 0.25 arcseconds.

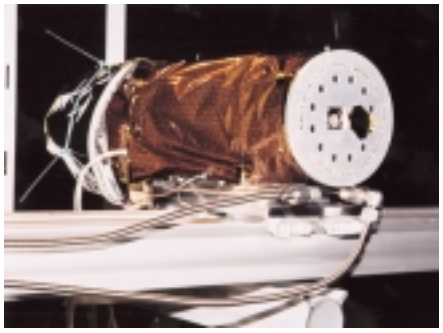
Focal plane instruments on track to preserve the highest resolution of which the telescope is capable (≤ 0.25 arcseconds).

Deliver x-ray telescope to ISAS by December 2003.

This metric is on track.

Solar X-Ray Imager

Another MSFC payload is the SXI, that flies on the NOAA Geostationary Operational Environment Satellite (GOES)–M satellite. The instrument serves as a solar activity monitor by imaging the x-ray emission from the Sun.



FY 2001 Solar X-Ray Imager Metrics and Performance

Launch Solar X-Ray Imager on GOES–M.

SXI was launched on GOES–M on July 23, 2001. SXI and the spacecraft completed post-launch testing and were placed in a storage mode on December 20, 2001, as a backup to the currently operational GOES spacecraft.

Mission lifetime of three years.

Metric on track and valid.

Full-disk soft x-ray imaging of the Sun, including solar flares and coronal holes.

Instrument performance was verified during post-launch tests.

Gamma-Ray Large Area Space Telescope Burst Monitor

Another MSFC payload is the GBM. The project is an international partnership project being conducted in conjunction with the Max Planck Institute (MPE)/ Germany. The primary objective for GBM is to enhance the science return of the GLAST Large Area Telescope in the study of gamma ray bursts (GRBs). The GBM will detect GRBs over a large solid angle and will measure the spectra of the bursts over a wide energy band and with high temporal resolution. GBM will also determine directions to the bursts such that repointing of the main instrument can occur.

FY 2001 Gamma-Ray Large Area Space Telescope Metrics and Performance

Launch in September 2005.

Launch was moved to September 2006 due to GLAST mission slip.

Mission lifetime goal of five years.

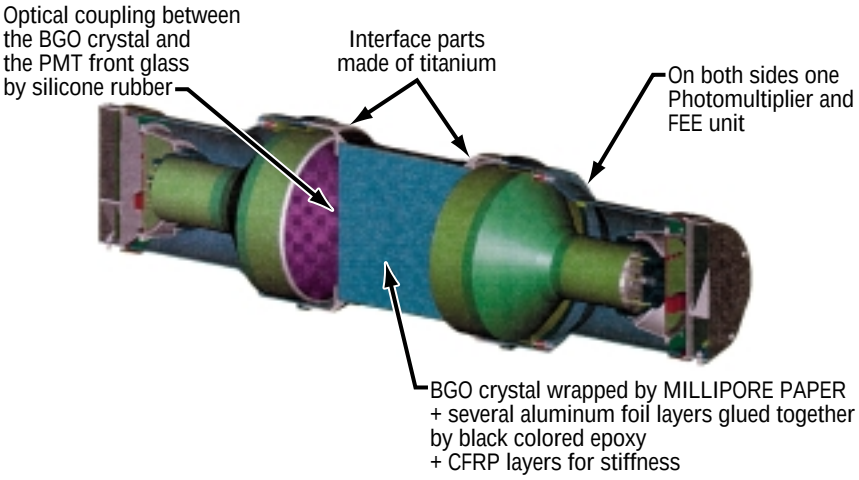
This metric is on track.

Detectors delivered by MPE by September 2003.

Detector delivery moved to July 2004 to accommodate mission slip.

Observe gamma ray bursts from 5 keV to 30 meV.

Metric was changed to measure gamma ray bursts from 10 keV to 30 meV to reflect the GBM requirement.



Design of the Bismuth Germanate (BGO) Detector Assembly.

Scientific Payloads and Research

Cosmic-Ray Astrophysics

Scientists at MSFC are studying high-energy calorimeter techniques for a future mission to measure the highest-energy nuclei in nature. The Advanced Cosmic Ray Composition Experiment on Space Station (ACCESS) experiment proposes to study the energy spectra and composition of galactic cosmic rays to reveal their source and the acceleration process that produces them. Together with colleagues from several universities, MSFC scientists have tested several detector concepts in a high-energy particle accelerator at the European Center for Nuclear Research.

Gamma-Ray Astronomy

The gamma-ray astronomy team at MSFC continues to analyze the wealth of data from GRBs and other transient and explosive phenomena from the Burst and Transient Source Experiment (BATSE) on the Compton Gamma Ray Observatory, which was deorbited in June 2000. Of particular interest for investigation have been the soft gamma-ray repeater class of objects and the galactic high-energy jet sources. BATSE has an extensive dataset of these observations and data from other spacecraft are used as well. Many of these analyses are made in collaboration with scientists from other universities. Simulations of relativistic jets in various astrophysical settings are underway by the MSFC team.

X-Ray Astronomy

Within the x-ray astronomy group, the engineering balloon flight of the high-energy-replicated-optics payload marked an important advance in our endeavor to provide low-cost, focusing x-ray optics for hard x-ray astronomy. Development successes this year included fabrication of the iridium-coated mirrors and the x-ray detector, and a unique day-night star camera for pointing these narrow field-of-view optics. Further balloon flights are planned as we begin the first efforts to study the hard x-ray sky with focusing optics.

Space Plasma Physics

With the launch of the IMAGE satellite, researchers can, for the first time, obtain images of the magnetosphere in energetic neutral atoms, extreme ultraviolet, and far ultraviolet wavelengths. The images are showing that the inner magnetosphere is a dynamic environment with unexpected features that scientists at MSFC are now analyzing. Global far-ultraviolet images of the aurora from the Polar satellite have revealed a correlation between the amount of energy deposited in the dayside ionosphere and the magnitude of the pressure enhancement in the solar wind. Aurora activity is observed only when the force exerted on Earth's magnetosphere by the solar wind exceeds a certain threshold.

Solar Physics

Solar activity prediction techniques were improved upon by MSFC solar scientists. Long-range predictions for the level of solar activity months to years in advance now provide reliable estimates. Short-term predictions for the likelihood of a solar flare, hours to days ahead of time, are facilitated by observations of the strength and direction of the magnetic field in the vicinity of a sunspot and by observations of S-shaped coronal structures in x-ray images of the sun. These improvements in solar activity prediction techniques provide a better understanding of the sun and its effects on life and society.

Astrobiology

Astrobiologists at MSFC collected microbial extremophiles from glaciers, permafrost, and cryoconite of North Siberia, Alaska, and the central Antarctic ice sheet. Strains of unusual microorganisms were isolated and grown in pure culture, including psychrophilic and psychrotrophic bacteria, archaea, cyanobacteria, fungi, and diatoms. These isolates are now being studied to determine if the microbial ecosystems of permafrost, glaciers, and cryconite rock/ice/water interfaces could provide models of possible life forms that might inhabit glaciers, permafrost, and polar ice caps of Mars, Europa, Ganymede, and other frozen worlds of the cosmos.

Principal Center Support Activities

NASA Automated Data Processing

In addition to operating and maintaining mainframe class computers and servers that support Agencywide administrative and programmatic processing requirements, the NASA Automated Data Processing Consolidation Center (NACC) supported the yearly financial audit of six NASA systems performed by PricewaterhouseCoopers (PwC). The NACC also supported the Marshall Space Flight Center (MSFC) Office of Inspector General audit of the Space Shuttle Systems.

Communications Architecture and Area Network Services

Digital Television.

The MSFC Digital Television (DTV) Project Office continued to support the team implementing the Space Act agreement with Dreamtime Holdings. The MSFC DTV Project Lead served as the NASA Principal Investigator for Dreamtime's High-Definition Television (HDTV) camcorder payload on Increment 3 aboard the *International Space Station* (*ISS*). Support for this project included providing documentation and training for the flight crew, checkout of the camera before flight, and postflight analysis. Planning began for an HDTV downlink capability currently scheduled to fly on the *ISS* aboard STS–114. A detailed plan was developed to migrate NASA TV from single channel analog to multichannel digital. Support was also provided to test integration of HDTV cameras into the existing operational television system at launch complex 39 at Kennedy Space Center (KSC).

Sustaining Engineering Support for Agencywide Administrative Systems

Sustaining Engineering Support for Agencywide Administrative Systems continued to provide sustaining engineering support to the Agencywide admin-istrative systems. Regulatory/statutory and policy changes were implemented expeditiously into the various applications, including the NASA Personnel/Payroll System, Consolidated Agency Personnel/Payroll System, Acquisition Management System, NASA Equipment Management System, NASA Property Disposal Management System, NASA Supply Management System, and the NASA AdminSTAR training system.

Logistics Business Systems Operations and Maintenance

Leadership was provided in implementing and sustaining Agency logistics business systems that provide the necessary automated tools to professionals supporting the NASA workforce. These logistics business systems provided responsive and cost-effective logistics business systems to all NASA strategic enterprises and logistic business process customers.

Earned-Value Management

During FY 2001 the NASA Earned-Value Management (EVM) Lead wrote and provided to NASA HQ a new NASA Policy Directive 9501.3 "Earned-Value Performance Management" and EVM Policy Guidance NPG 9501.(Draft), for their concurrence. In addition, the Lead Center wrote and coordinated with the Defense Contract Management Agency (DCMA) a joint Memorandum of Understanding (MOU) for EVM System surveillance. The MOU will provide a common framework for services NASA can expect when EVM System surveillance is delegated to DCMA. The EVM Lead Center also helped ensure promulgation of NASA EVM policy and procedures and helped standardize EVM practices across the Agency by chairing the NASA EVM Focal Point Council.

NASA Preferred Technical Standards Program

In FY 2001, the NASA Technical Standards Program Office continued to expand its support for the Agency's programs/projects by providing online technical standards products and associated information. The program office also implemented a new NASA Integrated Technical Standards Initiative approved by the NASA Chief Engineer.

This unique initiative consists of three key elements—an Agencywide full-text technical

standards system, a standards update notification system, and a lessons learned/best practices/applications integration system. Metrics and feedbacks from users of the systems, both from within MSFC and the Agency, indicate that the initiative has exceeded expectations relative to enhancing the access and utility of technical standards products in program/project engineering activities. MSFC's programs/projects and the Engineering Directorate have especially benefited. Increasing the integration of lessons learned/best practices/application notes will be a major goal for the NASA Technical Standards Program in FY 2002.

MSFC participation in non-Government standards-developing organizations increased by 10 percent over FY 2000. During FY 2001, the program office achieved a 150-percent increase in technical standards products developed, adopted, or identified for adoption as NASA-Preferred Technical Standards, exceeding the goal of a 100-percent increase.

Space Environments and Effects Program

Accomplishments for the Space Environments and Effects (SEE) Program in FY 2001 included the development of two contracts: 1) Testing and Optimization of Electrically Conductive Spacecraft Coatings and 2) A New Technique for Achieving Impact Velocities Greater Than 10 km/sec. Final reports are available in hardcopy format or electronic download from the SEE Program Web site.

Continued development of the NASA Charging Analyzer Program 2000 (NASCAP–2K), a collaborative effort between the SEE Program and the U.S. Air Force, will provide a detailed and comprehensive revision to the NASCAP spacecraft-charging analysis code. The FY 2001 effort was the third year of a 5-year development schedule. NASCAP–2K will provide grid resolutions and detailed analyses not achievable with other analysis techniques.

The year also saw the development and release of the SEE Program's third NASA Research Announcement that solicited proposals for the SEE Program and the Living With a Star: Space Environment Test-Beds Program. Fifty-two proposals were received, with 17 being awarded for a total of approximately $2 million for both programs. The awards are for 1-, 2-, and 3-year efforts. More information can be found on the SEE Program Web site.

Integrated Financial Management Program

The goal of NASA's Integrated Financial Management (IFM) Program is to improve financial management throughout the Agency. The mission of the restructured IFM Program is to improve the financial, physical, and human resources management processes throughout the Agency. IFM will reengineer NASA's business infrastructure in the context of industry best practices and implement enabling technology to provide necessary management information to support the Agency's strategic plan implementation. Successful implementation of the program will allow NASA to:

- Provide timely, consistent, and reliable information for management decisions.
- Improve accountability and enable full-cost management.
- Achieve efficiencies and operate effectively.
- Exchange information with customers and stakeholders.
- Attract and retain a world-class workforce.

Marshall Space Flight Center plays several major roles in the Integrated Financial Management Program.

Integrated Financial Management Core Financial Project

The Center manages the Core Financial Project, which is the first of several potential IFM projects. The IFM Core Financial Management Project provides the management and technical leadership for the Agencywide implementation of standard systems and processes necessary to support the Agency's financial management activities. The Core Financial Project will provide the backbone of the IFM Program and consists of the following components: Standard general ledger, accounts receivable, accounts payable, budget execution, purchasing, and cost management. In addition to managing the project, MSFC will serve as the pilot Center for implementation of the core financial software.

Integrated Financial Management Program Administrative Systems Implementation Project

MSFC has also been asked to manage the implementation of the remaining IFM Program projects that will utilize the SAP software suite. The IFM Program Administrative Systems Implementation Project will provide the management and technical leadership for the Agencywide implementation of standard systems and processes necessary to support the Agency's administrative activities. The scope of this project will include Human Resources (HR), Payroll, and Integrated Asset Management. The scope of the project will be finalized in FY 2003.

Integrated Financial Management Integration Project

MSFC also manages the long-term IFM Integration Project. This project manages all functional, application, and technical integration within the scope of the IFM Program. The IFM Integration Project is responsible for ensuring that the individual IFM software modules work together and collectively satisfy the defined Agency IFM business drivers. The Integration Project will also be responsible for maintaining the Agency business and software applications architecture, and designing and implementing the information technology architecture that supports the deployment and operation of the IFM modules.

NASA Materials Replacement Technology Team

The NASA Materials Replacement Technology Team (NMRT2) was formerly known as the NASA Operational Environment Team. One accomplishment of NMRT2 during FY 2001 was the development of the tools for training on CD-ROMS. The proceedings of the Fourth Conference on Aerospace Materials, Processes, and Environmental Technology (AMPET) were developed into CD-ROM format. These proceedings encompassed 106 technical papers on evolving materials, manufacturing, and environmental technologies essential for maintaining a competitive edge for upgrading existing systems and developing future airframe, propulsion, transportation, and structural hardware systems. The AMPET proceedings were distributed to the more than 500 engineers, scientists, and managers who attended the conference. Additionally, an inter-active CD-ROM training tool was developed from the results of the "NASA/Air Force/Environmental Protection Agency (EPA) Interagency Depainting Study." This study evaluated the performance of environmentally advantaged depainting technologies. Development and distribution of these training tools satisfied a tenet of the NMRT2 charter for serving as a clearinghouse for data/information pertaining to replacement technology.

NMRT2 also supported the "NASA Principal Center for Review of Clean Air Act Regulations." During 2001, NMRT2 provided Agencywide assessment and review of the impact of Clean Air Act regulations on NASA's programs and facilities. These emerging regulations encompassed hazardous emissions from operations such as rocket engine test firing, reinforced plastic composites, friction product manufacturing, and miscellaneous metal parts and products. Additionally, NMRT2 supported an EPA-sponsored public hearing to advocate the continued production of HCFC-141b material for manufacturing of the Space Shuttle's thermal protection system.

NMRT2 continued its partnership with the Shuttle Environmental Assurance (SEA) team and the Joint Group on Pollution Prevention (JGPP). The SEA initiative focuses on ensuring continued environmental compliance of Space Shuttle Program elements through awareness, communication, and resolution of environmental, materials obsolescence, and materials replacement technology issues. JGPP is a partnership between the Department of Defense (DOD), NASA, and industry with goals of reducing duplication of effort when testing alternatives to hazardous materials.

NASA Acquisition Internet Services

The NASA Acquisition Internet Service (NAIS), an Agencywide service under the leadership and technical expertise of MSFC, continued its trend of deploying procurement tools to the entire Agency. The following achievements are great examples of truly collaborative efforts among all NASA Centers serving in a team environment pursuing Agencywide standardization.

Interim Document Generation System

The Agencywide NAIS team delivered the Interim Document Generation System (IDGS) in FY 2001. IDGS is a Web-based system, enabling the contract specialist to generate solicitations and contracts. The contract-writing system will serve the Agency procurement community until a permanent solution is established in conjunction with the IFM Program. The contract-writing system had been one of the most sought-after solutions by Agency contracting officers and contract specialists for years. After an exhaustive review of several commercial off-the-shelf and Government-built systems, an existing Web-based system developed by Glenn Research Center was chosen to modify and deploy as a standard, Agencywide solution. After the decision was made, IDGS was deployed within only three months. Feedback from the centers has been very positive, and the NAIS team continued developing enhancements to address the various categories of contract acquisitions and functionality desired by the procurement community.

Contract Deliverables System

A major development within the NAIS Virtual Procurement Office project was the Contract Deliverables System (CDS), which enables the management and control of contract deliverables, primarily reports (e.g., progress reports, financial management reports). Following contract award, the contract administrator identifies deliverables, relevant focal points (e.g., responsible contractor representative, reviewers, approvers), and frequency. CDS enables the electronic submission of deliverables and the routing/approval process. It includes automatic e-mail notification to responsible contacts. It will be a key contract management tool integrated into the Virtual Procurement Office infrastructure established in 1999. CDS was rolled out for pilot testing at Stennis Space Center and will be deployed Agencywide later this year.

Request For Quote System Enhancements

The Request For Quote System is a Web-based capability enabling vendor transmission of quotes in response to simplified acquisition solicitations, which applies to all simplified acquisitions of commercial items between $25,000 and $5 million. It automatically generates the bid abstract of vendor quotes and the resulting purchase order. Several enhancements were made in FY 2001 to provide additional functionality for the buyer in completing the evaluation and selection of successful vendors.

Global Logon

Another FY 2001 achievement, Global Logon, is a strong, single-point authentication and authorization infrastructure that enables a single logon to all NAIS applications. The method capitalizes on the Agency-standard Public Key Infrastructure (PKI) digital signature. It also provides a Personal Identification Number alternative until such time as PKI is deployed Agencywide. Global Logon automatically manages the user accounts in a database infrastructure. This project enabled the NAIS team to satisfy Agency security requirements and minimize the administration costs associated with managing several thousand user accounts. Global Logon is the result of a Chief Information Officer-funded pilot project, which was supplemented by the existing NAIS team infrastructure.

Section 508 Compliance

The Rehabilitation Act of 1998 required Federal agencies to make electronic and information technology accessible to people with disabilities. Section 508 prescribed specific requirements to eliminate barriers in information technology. To meet this Federal mandate, the NAIS team conducted an impact assessment activity, and had to perform a significant amount of software modification throughout the NAIS suite as a result. The NAIS team accomplished the mandated objectives within the prescribed timeframe. The unfunded mandate was satisfied with existing NAIS resources.

Firewall Implementations

Throughout the year, the NAIS team was faced with new security requirements—primarily firewall implementations—that directly impact all NAIS operations. Given that NAIS serves the entire Agency as well as industry, a tremendous

amount of effort was required to modify the NAIS server hardware/software environment to survive the lockdown of Agency networks while maintaining the necessary access for the NASA procurement community, its customers, and industry.

Migration to the NASA Automated Data Processing Consolidation Center

In FY 2001, the NAIS team migrated all NAIS servers from an office facility to the NACC. As a result, the NAIS project gained system administration efficiencies, uninterruptible power supply, and increased network stability and reliability. Since completion of migration, efficiencies have already been experienced, particularly reduced interruptions in service.

NASA Integrated Services Network

In FY 2001, NASA Integrated Services Network (NISN) provided wide-area network video, voice, and data services to Agency customers at or above the established standards of excellence. In addition to managing services such as video teleconferencing; administrative and mission voice, facsimile, inter-Center mission and administrative data; and Internet access, significant effort was expended to meet new requirements for growing programs, such as the Earth Observing System, *ISS*, Gravity Probe-B, and Contour. NISN also provided telemedicine support for a medical emergency at the South Pole, for doctors at the University of Mississippi Medical School, and in Japan. NISN successfully demonstrated and implemented a point-to-point 1.5 Mbps video teleconferencing service between the NASA Administrator's office and astronaut crew facilities at Johnson Space Center (JSC) and KSC.

Video teleconferencing, voice teleconferencing, and facsimile services were successfully transitioned to a Small Disadvantaged Business contractor. NISN provided 4,835 Agencywide video teleconferencing sessions and 71,035 voice teleconferencing sessions in FY 2001, meeting operational performance objectives despite growing usage in these services. In FY 2001, NISN received 1,057 new requests for service and completed 880. NISN mission systems and operations staff supported shuttle launches STS–97, STS–102, STS–100, STS–104, and STS–105; two SEALAUNCH missions, SOYUZ/*ISS*–2A and –2S; five ATLAS missions; three TITAN IV missions; three DELTA missions; and one TAURUS mission.

In FY 2001, NISN implemented an electronic customer survey and a Web-based activity and outage posting and notification system and initiated cost-saving initiatives such as mission voice compression and customer requirements scrubs. NISN completed implementation of the isolated wide-area network at five NASA Centers. NISN updated its Security Management Plan to include the Internet Protocol Operational Network Security Plan; deployed incident detection/incident response intrusion detection systems at all NASA Centers, HQ, and peering sites; and merged the NASA Automated Systems Incident Response Capability function under the Program Information Systems Mission Services contract and tied to the NISN project.

Accomplishments of the Russian services team include automated large-area network auditing, significant personal computer refresh effort, support of the NASA Russian Space Agency and Penta Hotel Remodeling, support of the NASA Moscow Liaison Office Automation, replacement of the transatlantic circuits mission voice compression, significant infrastructure upgrades, and enhanced network security.

An annual customer forum was held to brief customers on service offerings and initiatives and to solicit customer input to improve NISN services and supporting processes.

Financial Management Support for Agency Contract Administration and Audit Services

MSFC has responsibility for NASA's financial management support for Agency Contract Administration and Audit Services (CAAS). This includes responsibility for managing the cost and billing information and Agency-level accounting data for CAAS services provided to NASA from audit organizations external to NASA. During FY 2001, MSFC revised the existing Contract Administration Management

Information System with new software providing a stronger, more efficient system for management of the cost and billing information. MSFC also has responsibility for NASA financial management support for Agency Reimbursable Collections of Contract Administration and Overhead from NASA reimbursable customers that provided reimbursement to MSFC salaries and NASA Federal Telephone Service costs.

National Center for Advanced Manufacturing

The Agency established the National Center for Advanced Manufacturing (NCAM) in FY 2000, giving MSFC the Principal Center designation for managing the initiative. NCAM has been created to ensure world-class capabilities exist for manufacturing future space transportation systems. NCAM is building a stronger manufacturing engineering organization, providing leadership for NASA and industry, ultimately enabling the development of space transportation systems with orders-of-magnitude improvement in safety, cost, and reliability. The concept of NCAM is defined by partnerships with other NASA Centers, Government agencies, academia, and industry. The inclusion of industry and education in this effort will improve technology and innovation transfer, and it will also ensure a trained workforce to help strengthen the U.S. position in the competitive marketplace. Accomplishments for FY 2001 include the continued partnership at MSFC's Michoud Assembly Facility (MAF) with the State of Louisiana, the University of New Orleans, and Lockheed Martin Corporation. A major accomplishment at MAF included the delivery of a highly advanced fiber placement machine to be used for research, development, production, and training. Preparation of the Government facility for installation of the machine and completion of classrooms and a videoconferencing center for teaching graduate-level courses in advanced manufacturing were significant achievements. The greatest success of FY 2001 was the formation of a university consortium to conduct research into advanced manufacturing techniques relative to space vehicles, with the University of New Orleans managing the effort. Other participants include Mississippi State University, Texas A&M, Tennessee Technological University, and Virginia Polytechnic Institute.

A partnership with Calhoun Community College continued to develop an intelligent manufacturing system that will allow virtual and collaborative engineering and training between Calhoun's new Advanced Manufacturing Training Facility and MSFC's NCAM facilities. Students trained in this facility will provide a technologically current workforce for the Boeing Delta IV plant in nearby Decatur, AL. Successful outreach within NASA with other Government agencies and with academic institutions in FY 2001 will provide the opportunity for many new partners in coming years, truly transitioning NCAM from regional to national prominence.

NASA Engineering Excellence Initiative

The NASA Engineering Excellence Initiative aims to lead a NASA-wide effort to define, measure, and involve engineering excellence across the Agency, with focuses on people, processes, facilities, and tools.

The Agency Systems Engineering Working Group (SEWG) is being led out of HQ/Code AE. The expectations of this working group are to help address Agency needs specific to consistency in the basic approach to systems engineering, a common framework of recognized best practices that guides the systems engineering of aerospace program and project products and capabilities, common systems engineering terminology and definitions to enhance communication and collaboration among engineering teams across the Agency and with external partners and customers, and providing a basis for assessing and continuously improving systems engineering capabilities. A member of the Systems Management Office provides MSFC representation on the SEWG. During FY 2001, the SEWG developed an outline of Agencywide systems engineering processes. This outline will be expanded into a draft NASA Procedures and Guidelines during FY 2002.

Other Support Activities

Spacelink

The NASA Spacelink Team was awarded the Frank G. Brewer Trophy at the National Congress on Aerospace Education in Minneapolis, MN, on March 15, 2001. The award was presented by the National Aeronautic Association, and is considered one of the highest aerospace education awards in the nation. The Brewer Trophy was established in 1943 and is awarded annually to an individual, a group of individuals, or an organization for significant contributions of enduring value to aerospace education in the U.S. This was only the third time in 58 years that the Brewer Trophy has been awarded to a team instead of an individual. NASA Spacelink, one of NASA's primary education Web sites, is managed by the MSFC Education Programs Department for NASA HQ, with the support of the Center Operations Directorate's Information Systems Department.

The Spacelink team contributed to NASA's "linkage campaign" for Global Science and Technology Week, an initiative of the White House Office of Science and Technology Policy. The goal of the linkage campaign, which was held May 6–12, 2001, was to coordinate the promotion of NASA information related to the *ISS* and the Sun-Earth Connection. The Spacelink team prepared a list of resources related to these two topics, modified the NASA TV education schedule to coordinate with the event, and was a partner in promoting the event through key areas of Spacelink.

Human Resource and Payroll Information Systems

HR representatives and the Consolidated Payroll Office, along with representatives from the Department of the Interior, continue to work closely together to federalize the SAP product. The schedule for implementation of HR/Payroll is under review to prevent any adverse impact to the Core Financial implementation project.

A new customer service tool has been made available in Employee Express for NASA employees. A short version of the NASA Leave and Earnings Statement can be viewed online or printed at the customer's discretion. There are plans to enhance the NASA Leave and Earnings Statement in Employee Express with more leave categories.

NASA Secure Network

Center Operations provided leadership and technical expertise by developing and implementing a dedicated NASA Secure Network (NSN). The NSN is a Web-based classified network encryption system with MSFC serving as the system host for the Agency. Beyond providing NASA with secure e-mail, file sharing, and classified processing of data/voice/video, the NSN is designed to provide secure Internet access to 2,300 intelligence community and DOD Web sites.

NASA Automated Data Processing Consolidation Center

During FY 2001, the NACC upgraded both Administrative Complementary Metal Oxide Semiconductor processors, which improved system response time. Each upgrade required detailed planning, extensive cross-organizational coordination, and exact execution. The results were a 100-percent success. The NACC also completed the migration of all systems to Virtual Tape System. Also, standard account codes were implemented for NACC personnel on 14 of 15 system images. This is critical for running fewer system images as IFM is implemented.

Environmental Assessments During FY 2001

Toxic Cloud Evaluation

The Environmental Engineering Department worked with KSC and the 45th Space Wing in assessing the public risk from potential toxic cloud exposure resulting from a launch abort/failure within the first 20 seconds of liftoff along nominal flight trajectory. Recommendations were made to the Range Commanders Council to consider a launch abort/failure an emergency response activity, and allow visitors to observe launches from the Causeway.

Environmental Functional Review.

In November 2001, NASA HQ conducted an Environmental Functional Review (EFR) of MSFC operations. The EFR identified no significant findings and 11 positive findings. As part of the review, an overall program health indicator was assigned to each program area. The MSFC EED was rated "healthy" for the overall environmental program management.

Agency Logistics Business Systems

Leadership was provided in implementing and sustaining Agency logistics business systems that provide the necessary automated tools to professionals supporting the NASA workforce. These logistics business systems provided responsive and cost-effective logistics business systems to all NASA strategic enterprises and logistic business process customers.

AdminSTAR

During FY 2001, MSFC provided leadership in implementing and sustaining a training administration business system across the Agency.

Engineering

The Engineering Directorate (ED) provides state-of-the-art engineering services for MSFC's product line directorates, supports scientific investigations that broaden knowledge of Earth and the universe, and performs advanced technology development across a broad array of technical disciplines. FY 2001 was an outstanding year for ED, with significant accomplishments in providing quality products and services in support of the Space Shuttle, Space Transportation, Flight Projects, and Science customers, as well as technology development through both independent and team efforts. These were accomplished by incorporating the Marshall Values into every aspect of the service provided.

Engineering Support for Space Shuttle

In FY 2001, ED was actively involved in engineering support and development activities for the Space Shuttle to help ensure improved reliability and continued success of the manned space flight program. A successful side-loads nozzle test was completed at the MSFC Nozzle Test Facility. This was the first nozzle test to ever measure both pressures and structural responses to such loads, and to tie a method for predicting side loads to those values. The newly designed high-pressure fuel turbopumps for the Space Shuttle Main Engine Block II engine flew successfully for the first time in June 2001. The ED, in collaboration with Pratt & Whitney, performed certification analyses of these new turbopumps.

In support of the External Tank (ET) Project, The friction stir welding (FSW) process characterization for the ET longitudinal welds was successfully completed. ED also completed a modification to the 14-ft. circumferential weld tool at MSFC to enable self-reacting FSW, and demonstrated this technique. This is an enabling technology for advanced aluminum cryotankage for the Space Launch Initiative program, as well as promising both cost reductions and significantly higher strength welds for ET. Working with Lockheed Martin, ED performed development trials for B218 weld wire, which was specially designed for the repair and welding of aluminum-lithium alloys. This weld wire is targeted for use on ET to increase repairability.

FSW was demonstrated for possible application to the repair of existing, or fabrication of new, Solid Rocket Booster (SRB) forward skirts. ED also completed a detailed structural test program to qualify both forward and aft SRB separation bolts provided by a new vendor. This activity involved test fixture design, test machine modifications, and planning and execution of the structural testing at the MSFC Structural Test Facility.

ED also led the SRB Integrated Electronic Assembly Supportability Assessment Team. The results of this team's efforts resolved some long-standing issues and provided well-received recommendations for both MSFC and JSC.

ED worked with Lockheed Martin –MAF to develop and implement High-Resolution Digital Radiography and Phased Array Ultrasonics technologies for Non-Destructive Evaluation (NDE) of the ET welds. This knowledge was also transferred to the Reusable Solid Rocket Motor (RSRM) program, where it is scheduled to replace the current wet-film technology and provide the NDE of phenolic-nozzle components, as well as loaded and insulated case motor segments. ED also supported development, implementation, and checkout of an automated eddy current inspection system for RSRM case hardware. This technique replaced magnetic particle inspection and provides higher detail of inspectability through enhanced detection and imaging software.

Engineering Support for Space Transportation

The ED supported a broad array of Space Transportation programs in the disciplines of avionics integration, navigation and control hardware and software, materials and processes, and design and analyses of the systems. The Flight Robotics Laboratory conducted separation bolt testing for the X–38 Deorbit Propulsion Stage. This is the first known use of air-bearing vehicles on a flat floor for characterization of pyrotechnic bolt separation forces. In support of the Orbital Express program, the Flight Robotics Laboratory also successfully performed the first automated docking test using two independently controlled "free-flying" modules.

ED performed technology development work to advance the state-of-the-art of very large, lightweight structures for application to advanced space transportation, space optics, and space solar power. ED completed several activities including inflation/deployment of thin film space booms, fabrication of foam-filled cylinders and tubular space booms, NASA Structural Analysis finite element modeling of foam-filled struts and 4- by 6-m inflatable antenna/concentrator, and modal testing of foam-filled struts. This technology resulted in the application for a patent for foam rigidization of inflatable structures by ED.

ED designed a Tether Winding and Spark Testing Facility to provide an in-house capability to test the conductive portion of the Propulsive Small Expendable Deployer System (ProSEDS) flight tethers. ED Departments successfully delivered all required products for the ProSEDS project and supported experiment integration and integrated testing.

Working very closely with Boeing, ED developed manufacturing processes in support of the metallic cryogenic tank technology program. ED also initiated an in-house testing effort to address the permeability issues for composite cryotanks. In an agency collaborative effort with the Jet Propulsion Laboratory to provide risk mitigation for flight hardware, ED performed fabrication of aluminum liners for composite tank testing at MSFC. In addition, skin trial tests were conducted by ED for the Northrop-Grumman composite tank as part of building block approach to further mitigate manufacturing risk.

For the Third Generation Reusable Launch Vehicle program, ED successfully fabricated the largest-ever ceramic matrix composite disk for the turbine blisk. In support of the In-Space Propulsion program, ED performed the first ever high-vacuum measurement of photo pressure on solar sails. ED also performed space environmental effects testing on solar sail candidate materials and measured the thermo-optical properties (solar absorptance and emittance) of these materials.

Engineering Support for Flight Projects

ED departments supported the *ISS* in several areas. Evaluation of the common berthing mechanism was performed after successful testing of the hardware in our environmental test facilities. As a result of a nickel-plating problem encountered by the European Space Agency, ED provided support in the problem resolution with defining and implementing successful process improvements. In support of *ISS*, ED developed models to evaluate the Space Station remote manipulator system. The Launch Deployment Assembly (LDA), which ED developed and manufactured in-house, flew successfully on Shuttle mission 6A in April 2001. The LDA provided structural support for the Space Station's Canadian Robot Arm and enabled successful on-orbit deployment. ED also authored Standard CD 14624–3, "Toxic Offgassing," which has been adopted as an international standard.

ED provided technical insight to the Environmental Control and Life Support System (ECLSS) including the Water Recovery System and Oxygen Generation System, and participated in the in-house design of the Urine Processor Assembly (UPA). ED testing and analysis support on ECLSS included corro-sion testing, H2 compatibility testing, loads and dynamic analysis, and hazards analysis.

The ED Environmental Test Facility performed over 150 separate tests in FY 2001 operating at a facility capacity of 283 percent (199 days of 24-hours-a-day, 7-days-a-week support). In addition to *ISS*, other programs supported included National Space Transportation System, ProSEDS, Fastrac Engine, Materials Science Glovebox (MSG), and High Energy Replicated Optics. Acceptance tests of all flight components for the *ISS* Node 3 common berthing mechanism were also completed. ED performed strength tests of flight hardware development program structures and components with major emphasis in the following: Shuttle attach bolts, hold-down struts, ET dome and composite thrust struts, the *ISS* UF–4 Multipurpose Experiment Support Structure, the LDA struts, Microgravity Captive Mechanism Assembly and Payload Restraint System, and the X–38 Deorbit Propulsion Stage joints and bolts.

Engineering Support for Science

In the area of science, ED provided expert engineering design, analysis, technical insight, and manufacturing capabilities in support of many varied programs. ED supported issue resolution and successful integrated testing, launch, and orbital evaluation of the Solar X-Ray Imager. On-orbit performance of this in-house development is exceeding requirements and all expectations.

As part of an extensive support effort for Gravity Probe–B, ED supported the successful modal survey test of the space vehicle, provided "tiger team" support for gas management assembly anomalies, and performed the contamination assessment.

ED served as part of an interagency team (Goddard Space Flight Center, Glenn Research Center, Langley Research Center, MSFC), which was formed to investigate candidate materials for the Next Generation Space Telescope sunshield. ED examined the space environmental effects on these materials, and based on their results and analyses, the number of candidate materials was reduced from six to two optimized materials.

ED provided the bulk of design, development, and manufacturing for in-house microgravity projects including First Materials Science Research Rack (MSRR–1), Quench Module Insert (QMI), and Glovebox Integrated Microgravity Isolation Technology. This work included support of the MSRR–1 Integrated Payload Critical Design Review in FY 2001. On QMI, ED matured the design beyond the challenges of high temperature materials and completed the drawing package for the ground unit.

On MSG, ED provided technical insight and engineering support and analysis in many areas, including electromagnetic interference and thermal, to help the European Space Agency meet the many engineering challenges inherent to this program. ED also participated in the software redesign and requalification effort for the Mechanics of Granular Materials hardware. ED provided engineering support for several structural biology programs. On Delta L, ED implemented the tools and principles of Multidisciplinary Design and Analysis to complete the design within 18 months.

Technology Development

In line with the core strategies and focusing on our technology thrust areas, ED was actively involved in technology research and development in FY 2001. The Directorate provided considerable support to the Technology Transfer Department by managing multiple Small Business Innovation Research activities, participating in the Technology Investment Program, and ensuring that newly-developed technologies were fully evaluated for their commercial potential. ED was also an active participant in the Center Director's Discretionary Fund program, working technologies with relevance to the product lines. ED employees were active in publishing and presenting scientific papers in trade journals and at technical conferences. Over 106 technical publications were written and released by ED personnel.

In the area of neural networks, ED incorporated methodology into several NDE processes, including ultrasonic resonance testing. ED personnel further enhanced their knowledge of fuzzy logic theory and fuzzy control, in an effort to apply this to future MSFC projects. ED developed software that allows more rapid reconfiguration of digital signal processor applications. In this effort, a process was developed such that the surface-mount flash erasable programmable read-only memory can be programmed without removal from the printed circuit card.

In FY 2001, ED developed the Generalized Fluid System Simulation Program. This general-purpose computer program for analyzing fluid flow in various kinds of complex fluid-distribution systems—including rocket engines, turbo pumps, and fuel tanks—won the NASA Software of the Year Award for 2001.

A precision penetration control system for the friction stir welding retractable pin tool, a panoramic detection system, and development of a system for multilayered composite pressurant tanks were just 3 of the 11 technological innovations that led to patents awarded to ED personnel in FY 2001.

This year, the ED also initiated an Independent Research and Development (IRAD) program. This program provides individuals or groups within ED the opportunity to conduct innovative research or technology development in technical areas relevant to ED's goals and objectives. The IRAD program also increases the technical readiness levels of proposed technology developments within the Directorate and enhances the capability of ED to better support the MSFC product lines.

ED also participated in a number of technology outreach and teaming opportunities. ED's partnership with the U.S. Army Aviation & Missile Command

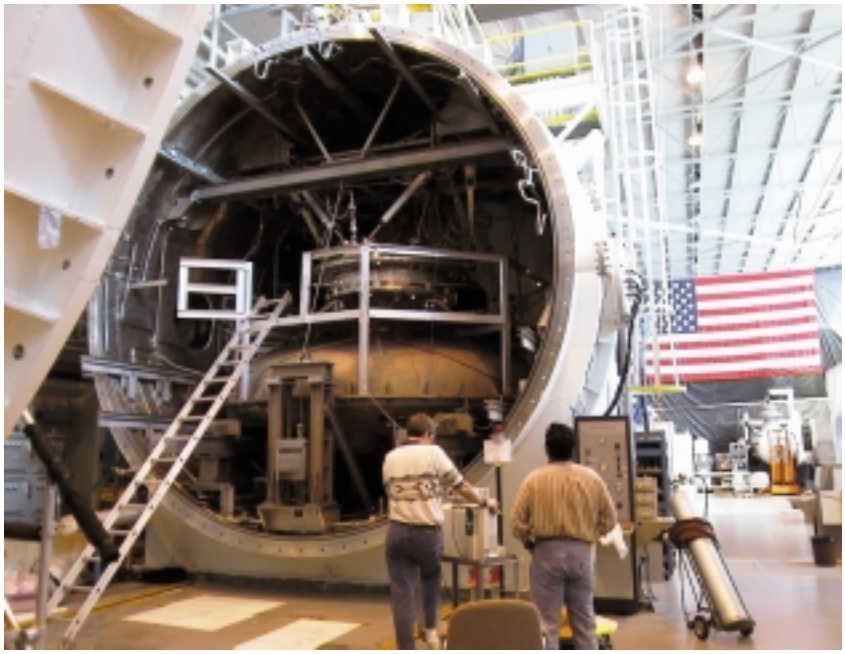
(AMCOM) was strengthened through increased efforts in the development and utilization of micro electromechanical systems. Tests were performed utilizing the 400-ft. outdoor antenna range in support of the Army Tactical Missile System to determine the susceptibility to jamming of the missile global positioning system guidance system. This partnership was further enhanced with a workshop that was conducted with AMCOM on the rapid prototyping processes performed within the two agencies.

Through a Space Act Agreement with Williams International, Inc., ED performed the initial friction stir welding feasibility demonstration of aircraft mockup parts being designed for the Eclipse Aviation Business jet. This design promises to revolutionize the business jet industry with a four-fold decrease in initial cost.

ED established the Thermal Development Facility (TDF) at MSFC, a new initiative that facilitates the development and implementation of aerospace thermal applications, technologies, and test methods. The TDF also provides a unique hands-on environment enabling thermal technologists to stay abreast of the latest thermal control/protection and test approaches, including alternate techniques not employed in MSFC programs.

ED retrieved and installed the Rome Air Development Center Cryogenics Test Facility into MSFC's Environmental Test Facility at a minimal cost (with payback expected within a year from test savings) and avoiding surplus of a first-class multimillion-dollar facility.

In another effort to enhance the utilization of ED technology-based capabilities, the Engineering Technology Development Office compiled a "Yellow Pages" directory that will assist in future planning activities and enhance communication within the directorate as well as with the MSFC product line directorates in relation to technology usage. Listed under alphabetized technology categories, the directory provides the names and phone numbers of the associated technology experts within ED.



FY 2001 Engineering Metrics and Performance

Increase the average hours of training by 10 percent compared to the FY 2000 baseline.

The total number of training hours for ED personnel increased from 16,110 in FY 2000 to 18,080 in FY 2001. This represents a 12 percent increase.

Increase ED membership in professional societies, membership on technical committees, and participation in professional conferences by at least 10 percent as compared to the FY 2000 baseline.

ED's membership in professional societies increased from 98 in FY 2000 to 146 in FY 2001. Membership on technical committees increased from 55 in FY 2000 to 56 in FY 2001. Participation in professional conferences increased from 134 in FY 2000 to 199 in FY 2001.

Increase the number of ED technical publications by 10 percent as compared to the FY 2000 baseline.

In FY 2001, ED personnel authored 106 technical publications. This represents an increase of 55 percent as compared to the 68 publications authored in FY 2000.

Increase the number of ED licensed Professional Engineers by 10 percent as compared to the FY 2000 baseline.

The total number of ED licensed Professional Engineers increased from 14 in FY 2000 to 15 in FY 2001.

Increase the relative number of ED patent disclosures by 20 percent as compared to the FY 2000 baseline.

In FY 2000, ED personnel had five patent applications filed, and five issued. In FY 2001, ED personnel had eight patent applications filed, with three licenses pending for ED technologies.

Achieve a score of 90 percent or better for customer satisfaction as determined by ED customer surveys of Marshall Space Flight Center product line directorates and offices.

In interview and Web-based customer satisfaction surveys, 96 percent of the respondents reported that they were very satisfied or satisfied with respect to ED's services.

Establish a minimum of 2 new teaming arrangements with industry, academia, other NASA Centers or Government agencies.

ED has established a collaborative partnership with JSC to provide a virtual engineering environment that will enhance both Centers' ability to leverage capabilities, streamline processes, and reduce design/development personnel resource requirements. A Trilateral Alliance among ED, Oak Ridge National Laboratory, and Arnold Engineering and Development Center has provided opportunities to leverage capabilities taking advantage of unique facilities and skills. A Memorandum of Agreement with AMCOM provides similar opportunity to leverage. Within ED, NCAM manages and supports a consortium of five universities focused on advanced manufacturing technologies. ED's NCAM has partnered with Calhoun Community College to enhance educational programs focused on advanced manufacturing. ED has partnered with Alabama A&M University to provide electronics equipment to support their engineering program.

Initiate and/or propose at least one new activity for ED to lead the Agency in a crosscutting engineering function.

ED continued leading NASA's Technical Standards Program. MSFC serves as the Lead Center for the Agency relative to the development, adoption, and data system management for the NASA Preferred Technical Standards products and associated standards activities in support of the Agency's programs/projects. The program implemented the Full Text and SUNS Alert Systems as new initiatives.

Initiate the transfer of at least two new technologies into the private sector.

Two manufacturers have licensed the Auto-Adjustable Pin Tool for FSW, developed in ED. This technology has improved the quality of the process for FSW of high-strength structural alloys. To overcome a drawback of the typical FSW process, ED engineers designed an automatic retractable pin tool that uses a computer-controlled motor to automatically retract the pin into the shoulder of the tool at the end of the weld, preventing keyholes.

Originally developed as a piston material to meet the U.S. automotive legislation requiring low exhaust emission, a NASA aluminum alloy developed and patented within ED now offers dramatic increase in strength at elevated temperatures. This technology has spread into the private sector for many applications as well as improving gas mileage and durability for auto engines.

Institutional Products and Services

Marshall Space Flight Center Technology Transfer

The Marshall Space Flight Center's (MSFC's) Technology Transfer Department utilizes focused program areas designed to innovate, incubate, and accelerate technological advances—from conception through development, demonstration, and commercial realization. It is a strategically focused program aimed at complementing the mission objectives of the Agency's enterprises and product lines, while ensuring that NASA's scientific and technological advances help to sustain the competitiveness of U.S. industry. This multifaceted program is fully aligned with the NASA Mission and Strategic Plan. The following paragraphs provide an overview highlighting the department's accomplishments in FY 2001.

NASA's Software of the Year Award garnered by MSFC.

The need for a flexible tool to analyze rocket engine fluid flow promoted the engineers at MSFC to invent the Generalized Fluid System Simulation Program (GFSSP). The flexibility, ease of use, and application to a wide variety of commercial industries garnered the powerful software a share of NASA's Software of the Year Award for 2001. A U.S. patent has been filed for this important software and potential licensees are in negotiation with NASA for commercial use of GFSSP.

Two MSFC innovations inducted into Space Technology Hall of Fame.

Two technologies from MSFC, video image stabilization and registration (VISAR) and compressed symbology, were inducted into the Space Technology Hall of Fame in 2001. The two selected technologies were awarded this technology "Academy Award" after undergoing a rigorous selection process. Only three technologies are inducted each year, and MSFC is honored to have two technologies receive this prestigious recognition.

The technologies selected for this award were VISAR—a new technology that dramatically improves images including crime scene videos—and compressed symbology—a two-dimensional symbol marking system capable of marking any material that needs to be tracked.

Facilities commercialization: Opening the doors for success.

MSFC has numerous unique scientific facilities and laboratories that are made available on a noninterference basis to educational and commercial partners under a cost reimbursement arrangement. The commercialization of these facilities is mutually beneficial for the partner and the Center. In FY 2001, an agreement was executed whereby a Personal Communication Systems base station antenna was installed at the Center. This installation resulted in improved wireless mobile phone service and market coverage for the partner and a $15,000 reimbursement to NASA.

STORMNet project helps National Weather Service predict future storm severity.

Eleven agreements were negotiated in FY 2001 to help create the STORMNet system. The STORMNet system uses a series of sensors to detect storm cell lightning and to provide real-time data to the National Weather Service and the North Alabama Emergency Management Agency. The information gathered by the system will be used to create models to help predict the severity of future events and assist emergency response groups in providing quicker response to storms. When fully operational, the system will save money, time, and lives.

Technology commercialization and licensing: The catalyst uniting technologies with commercial applications.

MSFC's Technology Transfer Department works to facilitate the patenting and licensing of MSFC-owned technologies and innovations, ensuring that their maximum commercial potential is realized. During FY 2001, MSFC filed 28 patent applications resulting in the issuance of 19 patents. Royalty income for the fiscal year was over $38,000, which brings the cumulative total in royalties earned by the Center to well over $185,000.

Software commercialization and licensing: Software releases maximize benefits to the nation.

NASA-developed software is commercialized and licensed through software usage agreements. These agreements ensure the software's release in a way that provides maximum benefit to the national economy. FY 2001 saw

MSFC set a new Center record in the award of 238 software usage agreements, which brings the cumulative number of such agreements to 538.

Center Director's Discretionary Fund: Promoting innovation in the workforce.
The Center Director's Discretionary Fund (CDDF) provides funding opportunities for well-defined research or technology development projects in scientific or technical areas. The projects must be innovative and support new ideas or concepts relevant to current or planned NASA programs, must be aligned with MSFC's roles and missions, and must clearly contribute to the core competencies of the technical workforce.

The projects are primarily performed in-house, involving outside groups or contractors only to the extent necessary. An important CDDF objective is to cultivate MSFC talent through hands-on experience. During FY 2001, 23 new projects were initiated and 21 former projects were continued with a combined expenditure of $2.2 million.

Technology Investment Program: Providing seed money to advance commercialization efforts.
The MSFC Technology Investment Program (TIP) is funded and managed by MSFC's Technology Transfer Department to underwrite high-risk technologies that support the NASA enterprises while also exhibiting high commercial potential. These technologies typically require an infusion of resources to increase their potential for commercialization. TIP works in conjunction with the Center's patenting and technology commercialization efforts, and maximizes the opportunities for commercial success of MSFC-developed innovations.

Projects selected for funding must be limited to in-house work, must have been formally disclosed, must demonstrate a high probability of commercial success, must be aligned with the roles and mission of the Center, and must be of one-year duration or less. In FY 2001, over $1 million was provided to MSFC product line organizations in support of 17 new projects.

New technology reporting: Capturing and sharing leading-edge technologies.
One of NASA's primary goals is to share leading-edge technology with the U.S. industrial community. The new technology reporting process provides an avenue for inventors to disclose their inventions, discoveries, and innovations. In FY 2001, 149 new technologies were reported and assessed for commercial potential, with $42,000 in incentive awards distributed to civil service and contractor inventors.

FY 2001 Institutional Products and Services Metrics and Performance

Establish 11 new partnerships that compliment MSFC's primary mission areas and leverage the limited resources available to the Center; negotiate four new licensing agreements that provide monetary value to the Center and its innovators; release 11 new success stories that highlight the technologies of the MSFC.	In FY 2001, the MSFC Technology Transfer Office established 38 new partnerships, released 16 success stories related to MSFC technology development, and worked on 4 new licensing agreements that were signed in November 2001.

Other Institutional Highlights

Special Events

MSFC sponsored a host of special events during FY 2001. The highlight was the 20th Anniversary of the First Space Shuttle Launch. Annual events supported during FY 2001 included the Moonbuggy competition, Retiree Dinner, Centerwide picnic, and Safety Day.

Home Security Awareness

In an effort to extend employee safety and security from the workplace to the home, MSFC Operations conducted "Home Security" presentations for personnel throughout the Center. As a result, we have increased the awareness and protection for our employees outside the workplace.

Property Accountability

Major improvements in property management processes were realized in FY 2001. Lost property rates were reduced dramatically due to reengineered and improved processes. Joint inventories were instituted which allowed partnering with Center contractors. A Centerwide Property Awareness Campaign was held in FY 2001 and continues to provide MSFC an accurate property accountability program.

MSFC Just-in-time Desktop Administrative Supply System

MSFC Center Operations implemented the Centerwide program for the new Web-based ordering system to purchase office supplies. The system allows representatives from each organization to electronically order office supplies for next-day delivery to the requestor's desktop. This system created efficiencies by allowing the closure of the office supply annex. The entire Center began using the system in FY 2001. Since initiation, the just-in-time (JIT) program has continued to grow in popularity, averaging 800 orders per month Centerwide.

Disposal Operations

FY 2001 marked the first full year of the disposal effort as a part of the Institutional Services Contract. The disposal team, consisting of contractor and civil service employees, processed over 12,100 items of equipment. The team was instrumental in facilitating the $11.2 million federal transfer of the Hopkins Ultra-violet Telescope to the National Air and Space Museum. There were 215 Federal transfers during FY 2001. State donations of $807,599 consisted of 227 items. The team transferred 2,597 items valued at over $6.2 million to 86 schools in the southern region surrounding MSFC. FY 2001 also brought a sales partnership with the General Services Administration and MSFC allowing for six sales of 6,299 items with proceeds of $103,967.

Critical Hardware Moves

In FY 2001, the MSFC Center Operations Directorate supported moves of program critical hardware. These moves included onsite as well as offsite moves via the NASA Super Guppy. The *ISS* oversized hardware included the S1 Truss Flight Article, S0 Truss Flight Article, the P4 Truss Flight Article, Z1 Truss Flight Article, and the node structural test article. Also, some smaller components were moved onsite for the *ISS* Regenerative Environmental Control and Life Support Systems Water Recovery System.

Pollution Prevention

The major CY 2001 accomplishment of the Pollution Prevention (P2) Program was the reduction in use and releases of one of MSFC's Toxic Release Inventory (TRI) reportable chemicals, tetrachloroethylene. The MSFC's vapor degreasing units have been removed from service and the process changed to use a more environmentally preferred solvent. Tetrachloroethylene is no longer a reportable TRI chemical for MSFC.

The primary focus of the P2 Program was to establish goals and requirements for compliance with Executive Order (EO) 13148. In CY 2001, NASA HQ Senior Management Council (SMC), in conjunction with the Principal Center for Acquisition Pollution Prevention at Kennedy Space Center, performed a preliminary analysis of MSFC's metal and photo finishing activities. Results of the analysis determined the potential for cost efficiencies and reduced environmental impact liability associated with the referenced operations. SMC recommendations were to outsource metal finishing processes to the private sector, convert wet photo processing to digital photography, and outsource remaining wet film processing offsite.

MSFC-affected organizations evaluated the recommendations and determined that some processes in the metal finishing area and photo processing operation could be outsourced or eliminated with process changes. The Plating Shop (Building 4760) is actively pursuing reductions in chromium and cadmium uses, and some plating vats have been converted to environmentally friendly substitutes. The Photographic Facility (Building 4353) has eliminated the use of some of its film processing solutions and undertaken the change to digital processing, with wet photo processing being sourced to local companies.

MSFC is continuing its chemical reduction efforts through the investigation and implementation of a JIT chemical procurement system. The Environmental Engineering Department (EED) spent several months evaluating chemical pharmacy operations, visiting chemical pharmacies at other federal facilities, and researching tracking software. The chemical pharmacy evaluation is a requirement of EO 13148. MSFC has determined that a JIT system is a preferred chemical management technique.

Environmental Assessments

During FY 2001 the MSFC EED conducted an environmental assessment for the new Propulsion Research Laboratory (PRL). Extensive evaluations and technical guidance were provided in support of the PRL's engineering study. Technical support was also provided to various other projects such as the Cryogenic Test Facility, Wellness Center, Construction-of-Facility (CoF) Projects, and Facility Work Requests.

Marine Operations

The Environmental and Engineering Management Department recommended and established goals in compliance of EO 13148 and submitted all environmental assessments and records of environmental consideration on time to support program requirements.

Superfund Cleanup

Under the Comprehensive Environmental Response Compensation and Liability Act program at MSFC, the characterization of groundwater contamination was completed and Remedial Investigation and Ecological Risk Assessment reports were submitted to the regulatory Agencies.

Evaluation of potential perchlorate use at MSFC was conducted and submitted to regulatory agencies.

In 2001, the MSFC EED presented a paper entitled *In situ Chemical Reduction Pilot Tests* at an environmental conference in Montreal, Canada. The Environmental Protection Agency invited MSFC to present the paper again at the North Atlantic Treaty Organization conference in Rome, Italy, in May 2002.

The Environmental and Engineering Management Department recommended and established goals in compliance of EO 13148, and submitted all environmental assessments and records of environmental consideration on time to support program requirements.

Onsite Medical Services.

To support a safe and healthy work environment, MSFC civil service personnel and onsite contractors were provided access, as dictated by the parameters of their jobs, to physical examinations, special screenings, immunizations, first aid, and emergency assistance. During FY 2001, approximately 10,000 patients received services at the MSFC Medical Center.

FY 2001 Construction-of-Facility Program

Funding was provided for two discrete CoF projects totaling $5 million and eight minor CoF projects totaling $8.25 million. All projects were awarded in the first quarter. This again met a very challenging performance metric established by NASA HQ reflecting the dedication and hard work of the Facilities Engineering Department Design and Construction Group. In addition, close management of the overall program resulted in the opportunity for the Center to receive approval and funding for an additional project in the amount of $1.5 million.

Propulsion Research Laboratory

The PRL study was completed in December 2000. When the original plan to negotiate a design contract with the architect/engineering firm that performed the study could not be accomplished, the Facilities Engineering Division was forced to negotiate with a second architect/engineering firm. Negotiations were successfully completed and the design contract was awarded in a timely manner, avoiding a

potentially major schedule impact to the design completion and the subsequent construction award. The design consists of one package for a new substation and one package for the new lab facility. Projected award dates are April 2002 for the substation contract and late FY 2002 for the facility contract.

Replacement Building 4600

A study was initiated in May 2001 for a building(s) to replace miscellaneous office/laboratory buildings at MSFC that are either currently scheduled, or being considered, for demolition. The study was completed in December 2001. A portion of the design funds was provided in FY 2001 with the balance to be provided in FY 2002. All design funds have been received and a contract for the design of the FY 2003 and FY 2004 phases (one building) is being negotiated. Construction is scheduled to begin in the third quarter of FY 2003.

New Facilities Master Plan

A new facilities master plan was funded in FY 2001 and is under development to provide a detailed framework for many aspects of facilities planning for the next 20 years. The master plan will take into account the significant mission shifts that have occurred at MSFC over the past few years. The focus of the plan will be land-use zoning, potential facility locations, campus development, transportation, and facility standards. The new plan is scheduled for completion in late summer 2002.

Security Training

In light of the unprecedented world events during FY 2001, additional training was required to equip personnel to meet potential challenges. Training for antiterrorism and anthrax was secured for appropriate members of the MSFC Team.

Identity theft training was also provided across the Center to alert MSFC employees of this increasing threat.

Information Technology Security

Significant progress was made by the MSFC Information Technology Security (ITS) Program, supporting elements, and MSFC organizations during FY 2001 in all areas of the Center's ITS posture, including program and policy development, training, risk management, engineering, and operations.

The NASA Office of the Chief Information Officer held a series of telephone interviews during FY 2000 to discuss ITS best practices and paths to improvement of the NASA ITS environment. Subsequent to these interviews, an action was given to NASA installations, in a memo dated August 18, 2000, to include in annual Center ITS plans additional information that reports on three selected best practices. The first of these reports was included in the FY 2001 Center security plan and are likewise included in the FY 2002 security plan.

Institutional Metrics and Performance

Center Operations Directorate

Ninety percent customer satisfaction by FY 2001.

NASA Automated Data Processing (ADP) Consolidation Center (NACC) provided highly available—99.9 percent—and cost-effective mainframe computing systems for 15 different Agency workloads during FY 2001. The NACC has a customer satisfaction goal of 95 percent. For FY 2001, the satisfaction percentage averaged 96 percent.

In FY 2001, Logistics Services completed the second year of their customer satisfaction survey process. The results of the survey identified a customer satisfaction percentage of 4.82 (96.4 percent) out of a perfect 5.0 (100 percent) rating. For the second year in a row, Logistics Services exceeded the Center Operations goal of 90 percent. Measurement criteria are timeliness, courteousness, knowledge, quality, meeting needs, and safety.

After a Centerwide survey conducted in FY 2000 indicated a customer satisfaction rate of 96 percent, the Facilities Engineering Department, based on electronic feedback during FY 2001, is proud to have maintained that rate for FY 2001.

Ninety percent services provided at competitive rates by FY 2001.

Information technology services offered at competitive rates during FY 2001 include applications programming support for both Marshall Space Flight Center (MSFC) and the Agency; MSFC telephone and long distance services, cell phones, and pagers (outsourced); NACC mainframe and midrange computing support; and services provided by the Central Reproduction area.

Logistics Services provides the Center with 21 services. Of the 21, 13 services can be compared to the commercial sector. Specialized services such as property support, mail, program critical hardware, and travel services cannot be compared in a competitive market. All 13 services were competitive and travel services continue to be monitored to determine competitiveness.

Perform annual building inspections and special inspections to ensure a healthy work environment.

Center Operations Managers performed routine inspections of buildings occupied by Center Operations employees and contractor employees, to identify and correct hazards. Recommended corrective actions to any safety findings are tracked from initiation to closure.

Make physical examinations, special screenings, immunizations, first-aid, and emergency assistance available to all employees.

All MSFC civil service personnel were provided access to physical examinations, special screenings, immunizations, first aid, and emergency assistance during FY 2001. In addition, onsite contractors (as dictated by their jobs) received physical exams, special screenings, and immunizations. All contractors were provided access to emergency assistance services. During the last year, approximately 10,000 patients were seen for exams and clinical visits.

Additional Center Operations Metrics

The goal for mainframe computing area system availability is 99.8 percent. In FY 2001, this goal was exceeded with an average of 99.9 percent.

The goal of achieving a baseline Information Technology (IT) Security basic awareness training for MSFC civil-service employees was 95 percent in FY 2001. An aggressive training program was conducted and resulted in a completion rate of approximately 99 percent.

The Facilities Engineering Department met the goal of 90 percent availability for primary mission related facilities in FY 2001.

The NACC exceeded its 95 percent availability goal for IT Services by achieving a 99.9 percent rating.

Customer and Employee Relations Directorate

In FY 2001 the Employee and Organizational Development Department increased Center developmental opportunities by 85 percent. This increase was fueled by a 193-percent growth in technology assisted learning programs.

	FY 2000	FY 2001
Classroom Training		
Offerings	1,057	756
Academic Studies		
Credit hours	3,700	13,305
Technology Assisted Learning		
Learning library offerings	559	673
Learning channel offerings	451	2,412
EMS offerings	109	135
Courseware offerings	0	56
Organizational Development		
OD interventions	N/A	N/A
Total Offerings	**2,176**	**4,032**

Technology Transfer Department

Technology development and deployment partnerships: Ingenuity at work.

The MSFC's Technology Transfer Department is discovering novel solutions for filling the technology needs of NASA, while supplying NASA ingenuity in ways that help America grow, through partnership opportunities with industry, small business, academia, and other Government entities.

The department also works to create partnerships through which educational and commercial partners may use MSFC facilities for a fee. There were 100 agreements active in FY 2001 of which 38 were new agreements. These agreements resulted in over $1 million of FY 2001 reimbursements to NASA. Of the active agreements in FY 2001, the cumulative reimbursements over the lifetime of the agreements were greater than $13.8 million.

Media Relations Department

MSFC's Media Relations Department exceeded its FY 2001 Implementation Plan metrics goals by a substantial margin. The goal of conducting a national news media campaign each month during the year, for a total of 12, was far exceeded, as a total of 43 such campaigns were conducted. During 2001 the department issued 384 news releases, fact sheets, and media advisories to more than 115,000 news organizations worldwide. Those releases and other news media contacts resulted in 2,542 known newspaper, magazine, television, Internet, and radio news stories in nearly 500 different U.S. cities in 47 states and the District of Columbia, reaching a total potential audience of more than 97 million readers and 646 million viewing households. The total dollar value of that coverage (excluding Internet stories) if purchased as advertising is estimated to be more than $4.5 million. More than 50 news releases were geared to minority audiences and resulted in stories reaching a potential audience of 21 million readers.

The metrics goal of directly communicating with 200,000 people nationwide at exhibit events was exceeded by more than 50 percent, with 353,000 visitors personally experiencing MSFC traveling exhibits at 93 events throughout the nation. Eleven of these were minority events attended by more than 23,000 people. In addition, the department arranged for a variety of NASA hardware and information to be on display at 59 museums nationwide, available for viewing by more than 15 million museum visitors.

Government and Community Relations Department

The Government and Community Relations Department achieved its primary objectives in FY 2001. The objectives centered around three areas including: briefing key stakeholders including Members of Congress on MSFC's mission areas and programs, increasing the Center Director's speaking opportunities and the speaking opportunities of other MSFC team members, and ensuring that MSFC's bus tour effectively communicated the Center's mission areas to the general public.

Each of these objectives contributed to the Government and Community Relations Department's overall goal—to promote understanding of NASA's missions and the role MSFC plays in ensuring the overall success of the agency.

The Government and Community Relations Department coordinated over 30 congressional briefings by the Center Director on the Integrated Space Transportation Plan (ISTP) and NASA's overall budget. Also, a top-level briefing was held for congressional staff on the ISTP. Over 100 congressional staff members attended the briefing.

During FY 2001, the Department coordinated the visit of 60 members of the Alabama Legislature to the MSFC. The legislators were given tours of the Center and briefed on MSFC's mission areas. Additionally, the Department coordinated outreach efforts aimed at six different associations comprised of state and local government officials. These efforts focused on describing the positive impacts of NASA research and technology has on state and municipal governments and American citizens. Hundreds of local and state elected officials were reached through these efforts.

The MSFC's Speakers Bureau is part of the Government and Community Relations Department. During FY 2001, the Speakers Bureau booked 182 speaking engagements for 65 MSFC employees. Approximately 20,000 citizens were reached through the MSFC Speakers Bureau. Topics were presented from all of MSFC's main mission areas.

Finally, the Bus Tour continued to operate during FY 2001 hosting over 150,000 guests through the MSFC. Many bus tour stops were enhanced during this time including the *International Space Station*, the Payload Operations and Integration Center, and the Rocket Park. However, due to the events of September 11, 2001, the MSFC Bus Tour has been suspended due to security concerns. Plans are underway during this downtime to further upgrade and enhance MSFC Bus Tour stops.

Education

Universities and colleges

In support of our nation's higher education institutions, the MSFC in FY 2001 funded 146 universities and colleges within the 50 states. Of these 146 universities and colleges, there were 506 active research grants and training activities with a total contract value of $830 million. The total obligations against these grants and training contracts for FY 2001 totaled $132 million.

In the state of Alabama, MSFC funded nine colleges and universities that held 98 active contracts. The total contract value equaled $150 million with a funded amount of $38 million for FY 2001. The universities and colleges in Alabama that were funded include: Alabama A&M University, Auburn University, Oakwood College, Trenholm State Technical College, Tuskegee University, University of Alabama in Birmingham, University of Alabama in Huntsville, University of Alabama in Tuscaloosa, and the University of South Alabama.

Nonprofit Institutions

The MSFC also had 57 awards with nonprofit institutions that totaled a contract value of $353 million across the 50 states. There were 31 institutions that held these 57 awards. A total of $71 million was funded to these nonprofit organizations for FY 2001.

In the state of Alabama, MSFC funded 13 nonprofit institutions that held 19 contracts and received $5 million in funding, with a total contract value of $30 million. The nonprofit organizations in Alabama that received funding were: Alabama Department of Environmental Management, ARC of Madison County, IIT Research Institute, Johnson High School, Lee High School, Madison Academy, NASA Exchange@MSFC, North Alabama Science Center, Inc., Randolph High School, Southern Research Institute, Sparkman High School, U.S. Space & Rocket Center, and Universities Space Research.

Combined universities, colleges and nonprofit organizations
The MSFC funded a total of $203 million on 177 universities, colleges, and nonprofit organizations throughout the U.S. for FY 2001. This amount of funding was placed on a total of 563 contracts.

Implement summer program for college undergraduates.

The MSFC Summer Undergraduate Practical Experience in Research (SUPER) and the NASA Undergraduate Student Research Program (USRP) were both implemented in 2001 to provide hands-on, challenging research experiences that stimulate continued student interest in the fields/disciplines and are aligned with NASA's research and development mission. USRP also:

- Encourages and facilitates student interest in future professional opportunities with NASA,
- Extends NASA's commitment to educational excellence,
- Strengthens and expands NASA and university collaboration,
- Provides research experience and new knowledge.

The 25 participants in the USRP/SUPER in 2001 at MSFC had representation from:

- 21 universities (2 are in Alabama) across the U.S. and Puerto Rico,
- 17 states and Puerto Rico,
- 13 males and 12 females,
- Ethnicity: 56% majority, 44% minority (African American, Hispanic, Asian, Indian, and other).

Agencywide Educational Support Activities

Develop a regional Educator Resource Center (ERC) Network Web site, which will enhance communication among the ERCs and establish a direct line of communication with MSFC.

A NASA MSFC ERC Network Web site was developed and went online during FY 2001. The Web site features links to each of MSFC's Regional ERCs located in Iowa, Missouri, Arkansas, Louisiana, and Tennessee. Customers visiting the Web site can get specific information on each Center's offerings, and can view an easy-to-read composite calendar of activities that are color-coded by state. The redesigned Web site led to a 25 percent increase in hits during FY 2001 over the previous fiscal year and has improved communication and networking capabilities among the ERCs.

Develop new methods of directing Web-surfing educators and students to NASA sites containing popular content sought by the educational community.

NASA's Education Homepage serves as the gateway for information regarding programs and services available to educators and students across the U.S. Over 399,000 electronic participants accessed the NASA Education Homepage during FY 2001, recording over 10.5 million hits and transferring 57 gigabytes of information.

NASA Central Operation of Resources for Educators (CORE) Web site provides the public access to more than 520 videocassette, slide, and CD-ROM programs, chronicling NASA's state-of-the-art research and technology.

During FY 2001, over 74,000 electronic participants accessed NASA CORE, recording over 1.89 million hits and transferring 12 gigabytes of information.

NASA Spacelink is an electronic library that provides easy access to information on nearly all public NASA Web sites as well as hosting electronic versions of NASA-developed curriculum support materials.

During FY 2001, over 1.62 million electronic participants visited Spacelink, recording over 64 million hits and transferring 514 gigabytes of information.

Other Staff Offices

Equal Opportunity

Increase workforce representation by five percent in underrepresented categories as defined in the Center's current Affirmative Employment Plan, provided MSFC receives hiring authority and a diverse pool of applications are received.

A total of 129 employees were added to the MSFC workforce in FY 2001. Of that total, 32 were white females, 9 black, 2 Hispanic, and 7 Asian. MSFC's Asian workforce was increased by 7.7 percent and white females' representation was increased by 5.8 percent. There remain some areas of underrepresentation

Improve the accessibility features in five of the Center's buildings and public access areas.

As individuals with disabilities are hired or have specific needs, reasonable accommodations are provided. For FY 2001 they include:

- An automatic button to operate the men's restroom door in the basement of Building 4200 was installed for an individual in a wheelchair relocated from the sixth floor to the basement of Building 4200. A new hallway door was also installed for his use.
- A unisex bathroom was constructed conforming to Americans with Disabilities Act standards on the seventh floor of building 4200.
- Several additional handicapped parking spaces were added at various buildings.
- A sidewalk and curb cut were added from Building 4203 to the Medical Center.
- A wheelchair lift, accessible parking spaces, and interior handrails along the corridor were installed in Building 4666.

In four MSFC buildings, improvements in accessibility features were accomplished.

Increase research participation with historically black and other minority universities by five percent, provided appropriate Agency resources are available for FY 2001.

Funding for minority institutions managed by MSFC remained constant due to funding constraints.

Office of the Chief Financial Officer

Goal: Serve as stewards of Government resources. Develop and maintain processes and systems that ensure accurate financial control across the Center.

Obligate 95 percent of authorized funding for the current program year.

MSFC obligations were 96 percent in FY 2001.

Cost 70 percent or more of the resources authority available to cost within the fiscal year.

MSFC cost was 83 percent in FY 2001.

Integrated Financial Management (IFM) Program: Implement the IFM Core Financial System at MSFC by September 2002.

The IFM Core Financial Project is on target to implement at MSFC immediately following yearend closeout in September 2002.

Legal

Ensure that all court-imposed filing dates are met.

The Office of Chief Counsel met all court-imposed filing dates in FY 2001. The successful use of summary judgment motions significantly reduced the amount of time MSFC personnel were required to spend in court proceedings.

Review financial disclosure forms within 60 days of submission.

Federal law required certain Government employees to file annual financial disclosure reports. These reports are required to be reviewed within 60 days of submission for the purpose of identifying and resolving potential conflict of interest issues. In FY 2001, more than 800 financial disclosure reports were submitted by MSFC personnel. All reports were reviewed by the Office of Chief Counsel within 60 days of their submission. In addition, Web-based or verbal ethics training was provided to personnel who were required to submit the financial disclosure reports.

Procurement

Small business programs: Leveraging America's entrepreneurial resources.

The goal of NASA's small business programs—the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs—is to strengthen the role of small businesses in meeting federal technology needs.

In FY 2001, 90 active SBIR Phase I and II contracts were in force with a total value of almost $13.2 million. There were also nine active STTR Phase I and II contracts valued at $1.1 million. In addition, 40 SBIR/STTR Phase III contracts were active in FY 2001 with a value of more than $21 million. Phase I awards are presented to determine the scientific and technical merit and feasibility of an innovation; Phase II awards are for the continuation of development of those innovations shown to be feasible in Phase I; and finally, Phase III covers those activities capitalized by non-SBIR sources of funding for the pursuit of private sector or Government sales.

Minority and Woman-Owned Business Initiative: Providing opportunities to this vibrant segment of our Nation's economy.

The Minority and Woman-Owned Business (MOB/WOB) Initiative is designed to promote technology development and deployment collaboration between NASA and these targeted technology-based companies. MOB/WOB expositions help celebrate the diversity, innovation, and imagination that these small businesses bring by introducing them to the NASA technical community. In addition, as MSFC's Small Business Technical Advisor, the Technology Transfer Department coordinates with the MSFC Procurement Office to review the technical content of procurement documents with an eye toward bringing the capabilities of this segment of our Nation's economy to bear on meeting the needs of our space program. In FY 2001, an Industry Day Briefing provided 150 attendees from 94 small businesses invaluable knowledge about the opportunities to partner with NASA to our mutual advantage.

Increase obligated funds available for performance-based contracts to 80 percent.

MSFC achieved 89 percent for performance-based contracts.

MSFC will award 20 percent of its dollars available for contracting to Small Business Concerns in FY 2001.

MSFC achieved 43.2 percent for Small Business Concerns in FY 2001.

MSFC will award 8 percent of it dollars available for contracting to Small Disadvantaged Businesses in FY 2001.

MSFC achieved 12.4 percent of Small Disadvantaged Business concerns in FY 2001.

Systems Management Office

Provide independent cost/economic assessments of 100 percent of Program Management Council reviewed formulation phase projects above $100 million.

The Systems Management Office (SMO) Cost Engineering Office has continued to provide cost/economic assessments in support of numerous MSFC projects. However, the Program Management Council (PMC) did not review any formulation phase projects above $100 million in FY 2001, therefore no economic assessments were performed in support of the PMC in FY 2001.

Systems Management Office *continued*

Revise NASA/Air Force Cost Model every 18 months to include the latest cost data and model enhancements.

Ten new missions have been added to the NASA/Air Force Cost Model database, and a redesigned user interface has been developed to increase the level of estimate completeness and ease of transfer of data in and out of the program. Also, new complexity generators have been developed for nine subsystems in the model. Other enhancements include process-based schedule estimating at the subsystem level, time phasing of cost at the subsystem level, and cost trade capability for "what if" scenarios.

Expand Resource Data Storage and Retrieval database by 5 percent per year.

The Resource Data Storage and Retrieval database has increased by 1,676 documents, reflecting a 7-percent increase for 2001.

Conduct one-day System Engineering/Project Management training courses for 600+ MSFC personnel and provide a four-day Web-based System Engineering training tool.

The SMO System Engineering Office conducted 18 one-day System Engineering Overview courses, in which 476 MSFC personnel were trained (357 civil servants and 119 contractors). A four-day system engineering workshop course outline was developed and a determination was made that interactive, classroom instruction will be more effective than a Web-based format. Limited progress on the workshop course development has been made due to resource priorities.

Provide System Engineering/ Project Management career development processes for 300+ MSFC engineers/managers.

A proposed System Engineering Development Program (SEDP) was drafted to guide the career development of all MSFC system engineers. This process was patterned after the existing Agency Project Management Development Program. The draft SEDP has been reviewed with managers from various MSFC directorates and training personnel from the Customer and Employee Relations Directorate. Work will continue on this effort as time and resource priorities allow.

Conduct independent annual reviews of at least six MSFC projects.

All project requests for independent reviews were met for FY 2001. SMO conducted two Independent Annual Reviews (IARs) and one Red Team Review of MSFC projects. SMO also supported an Agency IAR of a Goddard Research Center program and provided review board representation for numerous MSFC project design, safety, and flight acceptance/ certification reviews.

Outreach Activities

Sharing Our Story, Creating New Opportunities

An important part of the Technology Transfer Department's program is to inform potential customers about the ways that the Marshall Space Flight Center (MSFC) and NASA serve the space community, American industry, and academia. The activities designed to provide this knowledge are grouped under the umbrella of Technology Outreach.

During FY 2001, presentations were made at 59 technical conferences/events in 22 states with a combined attendance of more than 233,000, more than 870,000 hits were recorded on the MSFC Technology Transfer Web site, 16 articles highlighting MSFC technologies were published in *NASA Tech Briefs*, and 6 articles featuring MSFC appeared in *Spinoff 2001*.

NASA MSFC Boosts Alabama Economy With $829 Million in FY 2001 Expenditures

NASA's MSFC in Huntsville, AL, contributed $829 million to Alabama's economy in FY 2001. Included were $247 million in salaries for civil service personnel and related costs, as well as travel. Also included was $582 million spent on locally-procured services, prime contractor and subcontractor support, and local construction. The $829 million spent in Alabama was significantly more than the MSFC's expenditures in any other state.

In addition, NASA funding of approximately $94 million was spent in North Alabama for *International Space Station* (*ISS*) hardware development by The Boeing Co. Approximately $47 million funding was spent by MSFC on NASA programs where MSFC had a supporting role, and an additional $18 million was spent on programs where MSFC performed work for other agencies.

MSFC received approximately 15.5 percent—or $2.2 billion—of NASA's total budget of $14.3 billion during FY 2001. Of MSFC's budget, 73 percent was spent for Human Exploration and Development of Space including Space Shuttle and Space Station activities; 26 percent for Space Science, Earth Science, Aerospace Technology, and Biological & Physical Research activities; and the remaining 1 percent was spent on Strategic Support of MSFC Programs.

Since it was established in 1960, the MSFC has had budget responsibility for more than $69 billion. When yearly figures are adjusted for inflation, this total is equivalent to more than $169 billion in today's dollar value.

Approximately $70 million in retirement annuities were paid in 2001 to 2,460 MSFC retirees residing in Alabama, with 1,680 retirees in Huntsville and Madison receiving $47 million of that amount.

Through September 2001, the MSFC paid $5.2 billion in federal salaries since its creation in 1960. In 2001, MSFC civil service employees collectively paid about $31 million in Federal Income Taxes and about $7 million in Alabama State Income Taxes.

At the end of September 2001, MSFC's permanent and temporary civil service employees totaled 2,740, including employees at resident offices at prime contractor facilities and at NASA's Michoud Assembly Facility near New Orleans, LA.

Of that workforce, 2,262 were college graduates, with 1,487 holding bachelor's degrees. There were 183 employees with doctorate degrees and 592 with master's degrees in fields of engineering, science—predominantly mathematics and physics—as well as other disciplines, predominantly business administration.

During 2001, 23,653 contractor personnel engaged in work for the MSFC, including 3,264 in mission support, 11,141 on prime contract work and 9,248 as subcontractors and vendors. Of the total, 6,878 worked in Alabama. Additionally, 463 contractors were associated with *ISS* work being done by Boeing in Huntsville and 802 jobs relating to other NASA work supported by MSFC.

During FY 2001, 62,000 people toured MSFC, including educators, conference and symposium visitors, and news media. In FY 2001, the attendance at the Space & Rocket Center in Huntsville was 341,411. The Space & Rocket Center is MSFC's official NASA Visitor Center.

During FY 2001, more than 84,269 students and 20,263 teachers and faculty representing all 50 states

were reached through the operation of MSFC's education programs. The MSFC donated $5.5 million in research equipment and placed some $203 million on grants, contracts, and cooperative agreements through the education programs. MSFC recorded 609 incidents of education Partnerships and Collaborations with other Federal, state, and local programs; professional societies; nonprofit organizations; industry and contractor communities; and all levels—but primarily K–12—of the educational community. MSFC employees and retirees volunteered to participate in the NASA Project Learning About Science, Engineering, and Research Program, serving locally as speakers, tutors, consultants, and science fair judges. During 2001, MSFC Educator Resource Center had contact with 5,711 educators through workshops, on-site visits, postal, and electronic requests, distributing over 113,014 pieces of NASA-produced materials. The staff of the MSFC Educator Resource Center developed and delivered 153 workshops and overviews to 1,408 teachers and homeschool parents. Additionally, over 10.2 million participants were touched by electronic involvement in NASA's education program during FY 2001.

Another way MSFC gives back to the community is through monthly Red Cross Blood Drives, where 959 pints of blood were collected from civil service and on-site contractors in FY 2001. Also, MSFC civil service employees contributed $559,703 to the Combined Federal Campaign—$294,893 of the total was designated to help agencies in Alabama.

The MSFC achieved 41 years of operation in 2001.

MSFC looks to the future with dedication to continue its role as a vital contributor to America's future in space, while positively impacting local, state, and Federal economy.

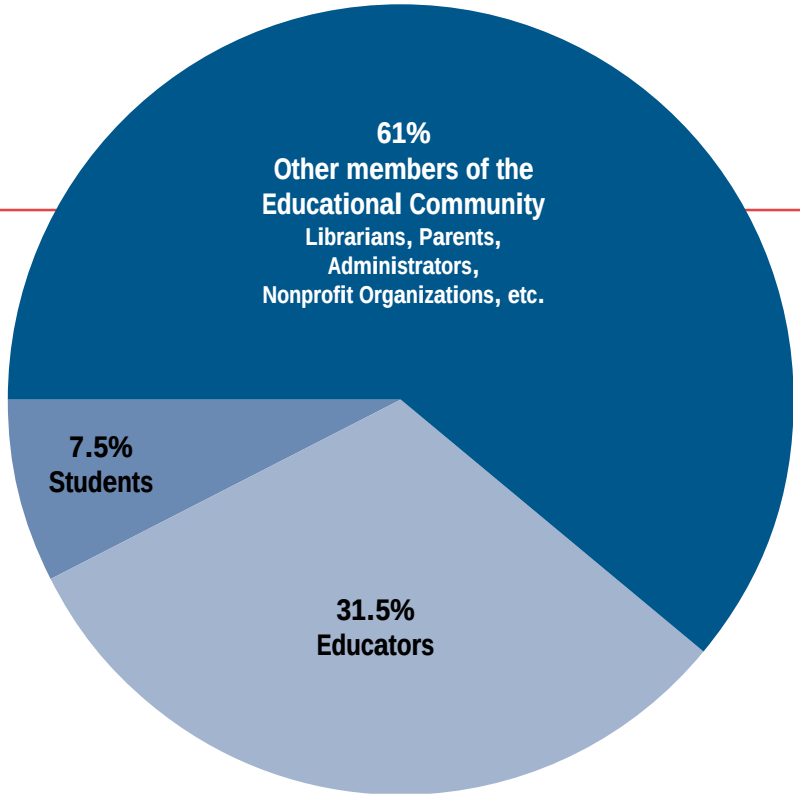
Education Outreach Activities

The successes of the Undergraduate Student Research Program (USRP) and the MSFC Summer Undergraduate Practical Experience in Research (SUPER) promoted ongoing research for six of the USRP/SUPER 2001 participants, with these individuals having received additional funding to continue the research started here at MSFC. This contributes to an effective workforce pipeline where one program moves students toward appropriate employment while also providing a talented workforce for NASA MSFC. The newly implemented MSFC Visiting Researcher Exchange and Outreach Program provided for a mechanism for working with a portion of those continuing students.

Continued improvements and expansions of the Great Moonbuggy Race yielded 77 registrants for 2001, with sustained growth having occurred since the 1998 race. The event is held annually each spring in Huntsville and asks high school and college students to address a series of engineering problems that are similar to problems faced by the original MSFC Moonbuggy team.

The first launches in the Student Launch Initiative, an educational program sponsored by MSFC, took place in October 2001. Three area schools launched 8-foot-tall rockets at a Redstone Arsenal test site, culminating a year-long project for the students. Randolph High School, Sparkman High School, and Johnson High School all provided launch vehicles. Johnson High School students also developed the science payload that was carried on all the launches. As part of the project, a panel of NASA scientists and engineers heard student presentations that were modeled after NASA flight readiness reviews. The goal of the Student Launch Initiative is to get high school students excited about and more directly involved in science, math, and engineering.

NASA/Marshall Education Programs Department
Total In-Person Involvement FY 2001



Total Participants:	**267,986**
Students	20,263
Educators	84,269
Educational Community	163,454

NASA/Marshall Education Programs Department
Total Electronic Involvement FY 2001

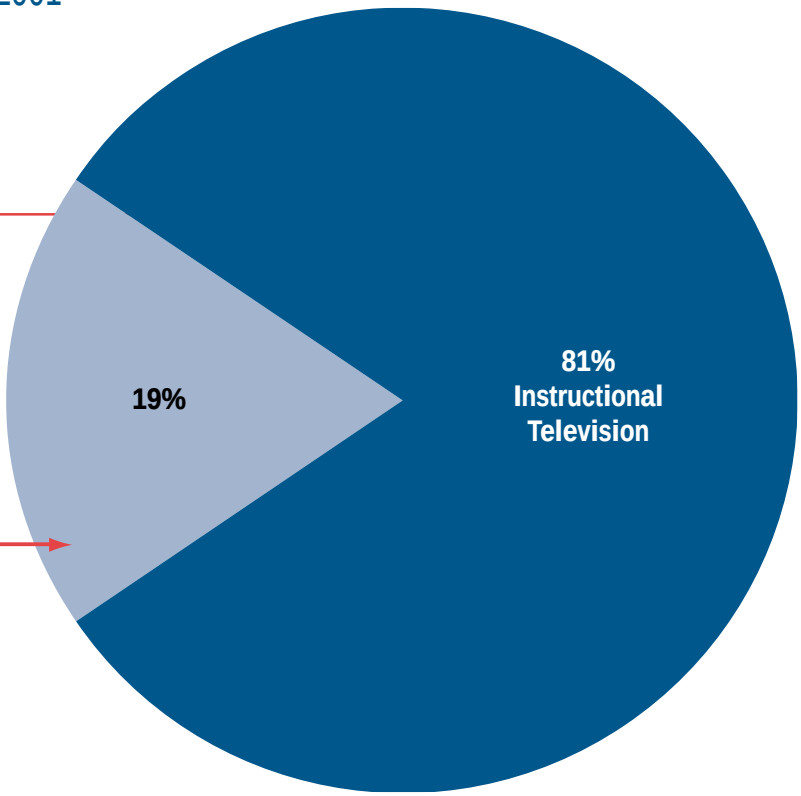
Total Participants: 10,245,010

Unique IP Addresses: 1,964,924

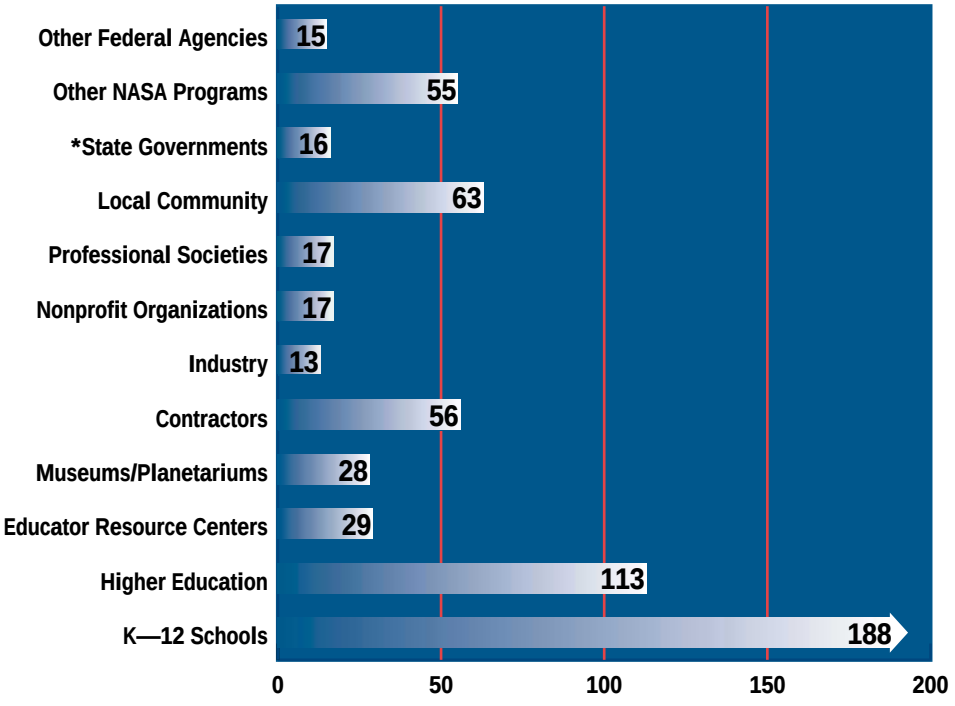
Instructional Television, Web casts, Videoconferences, etc. 8,280,086

Unique IP Addresses from Educational Web Sites

***Registered Viewers: 8,117,086 Students**
163,000 Educators



NASA/Marshall Education Programs Department
Number of Partnerships/Collaboration Incidents FY 2001

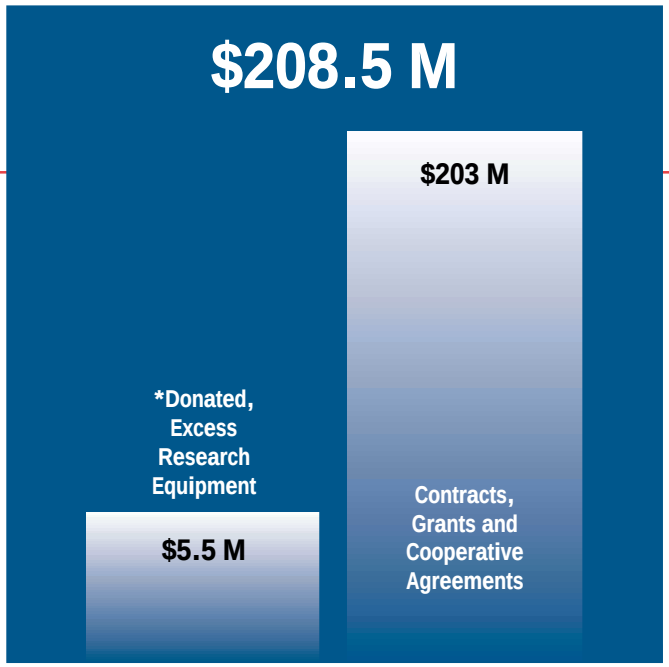


Total Incidents of Partnerships/Collaborations: 610

Total Number of Programs Reporting: 39

***With participants from all 50 states**

NASA/Marshall Education Programs Department Uses of Resources FY 2001



*Public K–12 School Districts:	54
Value:	$3,628,068
Post-Secondary Schools:	9
Value:	$1,891,463
Nonprofit Organizations:	1
Value:	$1,667

NASA/Marshall Education Programs Department Ratings of Excellence FY 2001

	Average Rating	Number of Participants	Number of Programs Reporting
Program Staff Rating	4.78	482	12
Would You Recommend the Program to Others	4.79	462	12
Expect to Apply What Was Learned	4.65	531	14
Program Was a Valuable Experience	4.80	2,438	17

Strongly Agree/Excellent	5
Agree/Good	4
Neutral/Average	3
Disagree/Poor	2
Strongly Disagreee/Very Poor	1

Science Communications Outreach Activities

FY 2001 was another excellent year for the MSFC's "OneNASA" science communications process and the Science@NASA family of Web sites. All of the Science@NASA Web sites showed an increase in readership during the year. All stories are carried both in written and audio format. The total number of hits (items that were downloaded by a customer) for all sites was over 610 million. The total number of visits (defined as consecutive pages downloaded to the same Internet address within a 15 minute period) was over 54 million. Visits can be loosely correlated to individuals coming to a site and downloading information.

For the main site (science.nasa.gov, or SNG), 139 stories were produced in FY 2001 covering all NASA Enterprises. Of these, 24 were recast to high school and to middle school levels and published on the Liftoff and NASAKids Web sites.

The new Spanish science service, Ciencia@NASA, carried Spanish translations of all SNG stories and registered 400,000 visitors in its second year of operation. This is NASA's first Spanish Internet presence dedicated to the whole of NASA research.

The Science@NASA family of Web sites was awarded the 2001 Pirelli International Award for "excellence in science communications and the spread of the science culture using the Internet."

The Science@NASA Web sites offer readers the opportunity to subscribe and receive notices when new stories are published. During FY 2001, the subscribers list for all Web sites included over 340,000 individuals, of which about one third were outside of the United States. After one year of operation, Ciencia@NASA had over 14,000 subscribers and had received the Yahoo!® International Award as the best Spanish language science and technology Web site for 2001. Science@NASA continued in 2001 to broadcast real-time audio to the Internet of various atmospheric and astronomical "songs." Visitors are able to listen to whistles from Earth's ionosphere, pings as meteors crash through our atmosphere, and "music" from storms in Jupiter's magnetosphere.

The individual sites registered hits/visits in 2001 as follows:

http://science.nasa.gov (SNG- adult science content)	110,000,000/12,000,000
http://liftoff.msfc.nasa.gov (satellite tracking and teen science content)	340,000,000/30,200,000
http://kids.msfc.nasa.gov (NASAKids Club site)	70,200,000/3,200,000
http://ciencia.nasa.gov (SNG stories in Spanish)	4,100,000/400,000
http://www.spaceweather.com (focused adult science content)	77,700,000/5,500,000
http://www.thursdaysclassroom.com (experimental education Web site)	5,500,00/764,000

Acronym List

Safety and Mission Assurance Acronyms

MSFC	Marshall Space Flight Center
OSHA	Occupational Safety & Health Administration
S&MA	Safety and Mission Assurance
SCRS	Safety Concerns Reporting System
SHE	Safety, Health, and Environmental
SSME	Space Shuttle Main Engine
SSWP	Supervisors' Safety Web Page

Center of Excellence: Space Propulsion Acronyms

MSFC	Marshall Space Flight Center

Space Transportation Systems Development Acronyms

AHMS	Advanced Health Management System
ASTP	Advanced Space Transportation Program
ATVC	Advanced Thrust Vector Control
BLS	Bureau of Labor and Statistics
CDR	Critical Design Review
CRD	Command Receiver Decoder
DOD	Department of Defense
ET	External Tank
FSW	Friction Stir Welding
GPS	Global Positioning System
HPFTP	High-pressure Fuel Turbopump
IEA	Integrated Electronics Assembly
IFA	In-flight Anomaly
ISAT	IEA Supportability Assessment Team
ISTP	In-space Transportation Plan
ISTAR	Integrated Systems Test of an Air-breathing Rocket
LH_2	Liquid hydrogen
LM	Lockheed Martin
LMSSC	Lockheed Martin Space Systems Company
lox	Liquid oxygen
MAF	Michoud Assembly Facility
MSFC	Marshall Space Flight Center
NDE	Nondestructive Evaluation
NGLS	Next Generation Learning System
NRA	NASA Research Announcement
OSHA	Occupational Safety & Health Administration
ProSEDS	Propulsive Small Expendable Deployer System
PRL	Propulsion Research Laboratory
PRR	Program Requirements Review
RBCC	Rocket-based Combined Cycle
RFP	Request for Proposals
RLV	Reusable Launch Vehicle
RSRM	Reusable Solid Rocket Motor
SDR	System Definition Review
SIO	Shuttle Integration Office
SLI	Space Launch Initiative
SRB	Solid Rocket Booster
SRR	System Requirements Review
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Projects
SSWP	Supervisors' Safety Web Page

Microgravity Acronyms

BEC	Bose-Einstein Condensate
bFCF	basic fibroblast growth fact
BUNDLE	Bridgman Unidirectional Dendrite in Liquids Experiment
CBSE	Center for Biophysical Sciences and Engineering
CCACS	Commercial Applications of Combustion in Space
CSC	Commercial Space Center
ESA	European Space Agency
EXPRESS	Expedite the Processing of Experiments to the Space Station
FBI	Federal Bureau of Investigation
GRC	Glenn Research Center
IBC	Iterative Biological Crystallization
ISS	*International Space Station*
JSC	Johnson Space Center
KSC	Kennedy Space Center
MIT	Massachusetts Institute of Technology
MRP	Microgravity Research Program
MRPO	Microgravity Research Program Office
MSAD	Microgravity Science and Applications Department
MSC	Microgravity Shuttle Combustion
MSFC	Marshall Space Flight Center
MSRR–1	First Materials Science Research Rack
OBPR	Office of Biological and Physical Research
NIH	National Institutes of Health
NISB	NASA Institute for Structural Biology
NRA	NASA Research Announcement
PCS	Physics of Colloids in Space
PERS	Payload Equipment Restraint System
PI	Principal Investigator
PTP	protein tyrosine phosphatase
RDR	Requirements Definition Review
SACA	Sample Ampoule Cartridge Assembly
SAL	Spread Across Liquid
SCR	Science Concept Review
SDC	Solidification Design Center
SPD	Space Product Development

Space Optics Manufacturing Acronyms

AMSD	Advanced Mirror System Demonstrator
GSFC	Goddard Space Flight Center
NGST	Next Generation Space Telescope
NMSD	New Mirror System Demonstrator
MSFC	Marshall Space Flight Center
SOMTC	Space Optics Manufacturing and Technology Center

Other Programmatic Assignments Acronyms

ACCESS	Advanced Cosmic Ray Composition Experiment on Space Station
AMSU	Advanced Microwave Sounding Unit
ASI	Italian Space Agency
BATSE	Burst and Transient Source Experiment
BGO	Bismuth Germanate
ECLSS	Environmental Control and Life Support Systems
EXPRESS	Expedite the Processing of Experiments to Space Station
GBM	GLAST Burst Monitor
GHCC	Global Hydrology and Climate Center
GLAST	Gamma-Ray Large Area Space Telescope
GOES	Geostationary Operational Environmental Satellite
GP–B	Gravity Probe–B
GRB	gamma ray bursts

Other Programmatic Assignments Acronyms *continued*

HEDS	Human Exploration and Development of Space
HTCI	HEDS Technology Commercialization Initiative
IMAGE	Imager for Magnetopause-to-Aurora Global Exploration
ISAS	Institute of Space and Astronautical Sciences/Japan
ISS	*International Space Station*
ISTP	International Solar-Terrestrial Physics
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAT	Large Area Telescope
LIS	Lightning Imaging Sensor
MPE	Max Planck Institute/Germany
MPLM	Multipurpose Logistics Module
MSFC	Marshall Space Flight Center
MSU	Microwave Sounding Unit
NOAA	National Oceanic and Atmospheric Administration
NSSTC	National Space Science and Technology Center
SERT	SSP Exploratory Research and Technology
SSP	Space Solar Power
SXI	Solar X-Ray Imager
TIDE	Thermal Ion Dynamics Experiment
TRMM	Tropical Rainfall Measurement Mission
UVI	Ultraviolet Imager
WRS	Water Recovery System

Principal Center Support Activities

ADP	Automated Data Processing
AMCOM	Aviation & Missile Command
AMPET	Aerospace Materials, Processes, and Environmental Technology conference
CAAS	Contract Administration and Audit Services
CDS	Contract Deliverables System
DCMA	Defense Contract Management Agency
DOD	Department of Defense
DTV	Digital television
ECLSS	Environmental Control and Life Support System
ED	Engineering Directorate
EED	Environmental Engineering Department
EFR	Environmental Functional Review
EPA	Environmental Protection Agency
ET	External Tank
EVM	Earned-Value Management
HDTV	High Definition Television
HR	Human Resources
IDGS	Interim Document Generation System
IFM	Integrated Financial Management
IRAD	Independent Research and Development
ISS	*International Space Station*
JGPP	Joint Group on Pollution Prevention
JSC	Johnson Space Center
KSC	Kennedy Space Center
LDA	Launch Deployment Assembly
MAF	Michoud Assembly Facility
MoA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSFC	Marshall Space Flight Center
MSG	Microgravity Science Glovebox
MSRR–1	First Materials Science Research Rack
NACC	NASA ADP Consolidation Center
NAIS	NASA Acquisition Internet Services
NASCAP–2K	NASA Charging Analyzer Program 2000

Principal Center Support Activities *continued*

NCAM	National Center for Advanced Manufacturing
NDE	Nondestructive evaluation
NISN	NASA Integrated Services Network
NMRT2	NASA Materials Replacement Technology Team
NOET	NASA Operational Environment Team
NSN	NASA Secure Network
PIN	Personal Identification Number
PKI	Public Key Infrastructure
ProSEDS	Propulsive Small Expendable Deployer System
PwC	PricewaterhouseCooper
QMI	Quench Module Insert
RLV	Reusable Launch Vehicle
RSRM	Reusable Solid Rocket Motor
SEA	Shuttle Environmental Assurance
SEE	Space Environments and Effects Program
SEWG	Systems Engineering Working Group
SRB	Solid Rocket Booster
TDF	Thermal Development Facility

Institutional Products and Services Acronyms

CDDF	Center Director's Discretionary Fund
CoF	Construction-of-Facility
EED	Environmental Engineering Department
EO	Executive Order
GFSSP	Generalized Fluid System Simulation Program
ITS	Information Technology Security
JIT	Just-In-Time
MSFC	Marshall Space Flight Center
P2	Pollution Prevention
PRL	Propulsion Research Laboratory
SMC	Senior Management Council
TIP	Technology Investment Program
TRI	Toxic Release Inventory
VISAR	video image stabilization and registration

Institutional Metrics and Performance Acronyms

ADP	Automated Data Processing
CORE	Central Operation of Resources for Educators
ERC	Educator Resource Center
IAR	Independent Annual Review
IFM	Integrated Financial Management
IT	Information Technology
MSFC	Marshall Space Flight Center
MOB/WOB	Minority- and Woman-Owned Business
NACC	NASA ADP Consolidation Center (NACC)
PMC	Program Management Council
SBIR	Small Business Innovation Research
SEDP	System Engineering Development Program
SMO	Systems Management Office
STTR	Small Business Technology Transfer
SUPER	Summer Undergraduate Practical Experience in Research
USRP	Undergraduate Student Research Program

Outreach Activities Acronyms

ISS	*International Space Station*
MSFC	Marshall Space Flight Center
SUPER	Summer Undergraduate Practical Experience in Research
USRP	Undergraduate Student Research Program

2001 Annual Report Points-of-Contact

CaER Directorate	Michael McLean	4–0397	4200/101C
ASRI/CD40	Mike Herston	4–0369	4200/G30
Center Operations Directorate	Patrick Rasco	4–8027	4200/420C
Flight Projects Directorate	David Smitherman	961–7585	NSSTC
Space Launch Initiative Office	Jerry Cook	4–1229	4203/5201
Procurement Office	T. Jerry Williams	4–0295	4202/200A
Systems Management Office	Steve Newton	4–9010	4201/624B
Science Directorate	Ron Koczor	4–3078	4201/500B
Office of Chief Financial Officer	Kim Jeffreys	4–0114	4200/812B
Space Transportation Directorate	Paul Crawford	4–9153	4203/6313
Safety & Mission Assurance Office	Judy Guin	4–5397	4202/301A
Equal Opportunity Office	Billie Swinford	4–0087	4200/716D
Office of Chief Counsel	Lonia Moore	4–0023	4200/149H
Shuttle Projects Office	Randy Sacks	4–0334	4202/417
Engineering Directorate	Mary Nehls	4–1003	4200

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NP–2002–10–175–MSFC
Pub 8-40078